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TRANSACTIONS

OF THE

Illinois State Academy of Science

SIXTH ANNUAL MEETING

at the

BRADLEY POLYTECHNIC INSTITUTE

PEORIA, ILLINOIS, FEB. 21-22, 1913

VOLUME VI

1913

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OFFICERS AND COMMITTEES FOR 1913-1914.

President, FRANK W. DE WOLF, Director State Geological Survey, Urbana.
Vice-President, H. S. PEPOON, Lake View High School, Chicago.
Secretary, EDGAR N. TRANSEAU, Eastern State Normal School, Charleston.
Treasurer, JOHN C. HESSLER, James Millikin University, Decatur.

The Council.

President, Past President, Vice President, Secretary, and Treasurer.

Publication Committee.

President, Secretary, Treasurer, and S. A. Forbes.

Membership Committee.

C. B. Atwell, Chairman, Chicago.
H. G. Gale, Chicago.
C. W. Finley, Macomb.
D. F. MacFarland, Urbana.
J. P. Gilbert, Carbondale.

Committee on Conservation.

H. S. Pepoon, Chairman, Chicago.
John G. Coulter, Bloomington.
E. N. Transeau, Charleston.

Committee on Legislation.

T. W. Galloway, Chairman, Decatur.
Otis W. Caldwell, Chicago.
E. W. Payne, Springfield.
Elmer J. Kneale, Springfield.

Committee on Calendar Reform.

T. C. Chamberlin, Chairman, Chicago.
F. R. Moulton, Chicago.
A. R. Crook, Springfield.
C. G. Hopkins, Urbana.
E. J. Townsend, Urbana.

Committee to Arrange for the Editorship and Publication of a Series to be Known as the State Academy Leaflets on High School Science.

T. J. McCormack, Chairman, Principal, La Salle-Peru High School, LaSalle.
William C. Bagley, Director of Education, University of Illinois, Urbana.
John G. Coulter, Bloomington.
H. S. Pepoon, Lake View High School, Chicago.
R. D. Salisbury, University of Chicago, Chicago.

Committee on Ecological Survey.

Stephen A Forbes, Chairman, University of Illinois, Urbana.
H. C. Cowles, University of Chicago, Chicago.
T. L. Hankinson, Eastern Illinois State Normal, Charleston.
V. E. Shelford, University of Chicago, Chicago.
E. N. Transeau, Eastern Illinois State Normal, Charleston.
Charles C. Adams, University of Illinois, Urbana.
Frank C. Baker, Chicago Academy of Sciences, Chicago.
H. S. Pepoon, Lake View High School, Chicago.
George D. Fuller, University of Chicago, Chicago.

Minutes of the Sixth Annual Meeting

Peoria, Illinois, February 21 and 22, 1913

SESSION OF FRIDAY, FEBRUARY 21, 2:00 P. M.

The meeting was called to order by President Crew. Dean Burgess of the Bradley Polytechnic Institute gave a short address welcoming the Academy to the Institute. President Crew responded briefly.

REPORT OF THE SECRETARY.

Minutes of Previous Meeting.—The fifth annual meeting of the Illinois Academy of Science was held at Bloomington, Illinois, February 23 and 24, 1912. The Academy met with the McLean County Academy of Science, a local organization which proved unusually effective in facilitating the work of the State Academy. The minutes of the business transacted at this meeting are published in full on pages 11 to 20 of Volume V, Transactions of the Illinois Academy of Science, and the scientific papers compose the rest of the volume; hence further presentation of the minutes at this time need not be made.

Meeting of the Council.—On June 11, 1912, a meeting of the Council was held in Chicago. Various matters relating to the welfare of the Academy were discussed. The secretary was instructed to prepare a folder-circular setting forth the purposes of the Academy, and to distribute this circular amongst the members, and elsewhere, in order to give more definite and widespread ideas regarding the work for which the Academy exists. This statement was prepared and distributed widely. Various other phases of the Academy's interests were considered informily.

The Council voted unanimously to recommend the election to membership of nine applicants, final action to be dependent upon the favorable vote of the Acadmy at its next annual meeting.

Publications.—The annual volume, Volume V of the Transactions has been published and a copy mailed to each member. In a few cases changes in address, of which the secretary was not advised, have occasioned delay or failure in receiving the volume. The supply on hand is sufficient to enable us to correct such erors if we are informed of them. One arratum slip, made necessary through a typist's error correcting the word "nine" in line 5, page 42, to read "twenty-three", was mailed to each member, and each one is urged to make certain that the needed correction is placed in his copy of the volume. Fifteen hundred copies of the volume were secured. In addition to copies sent to members a copy was sent to each member of the State Legislature; also, a circular letter to the high schools of the State gave an outline of the contents of the volume and offered to send it to the high schools upon receipt of postage. A good many have responded, and requests are still arriving.

As directed by the vote of the Academy last year, the secretary has issued a letter to the members asking suggestions regarding the place for this meeting, and whether a symposium should be included in the program. Of those who replied all but two favored the inclusion of the symposium, and the majority favored Peoria as the meeting place.

Membserhip.—At the meeting two years ago, 34 new members were elected. At the meeting last year, 46 members were elected. It should be stated that new members in the Academy have been secured each year almost wholly through the activities of three or four members who have given the matter personal attention. The present membership mailing list of the Academy includes 395 names. There are over five hundred schools in the State which should average at least one member each in the Academy, and from the college, university, normal school and medical men, five hundred more would give but a fair representation. Furthermore, the citizens of the State are interested vitally in many of the activities of the Academy, and the campaign for the extension of the influence of the Academy should be continued.

Respectfully submitted,

OTIS W. CALDWELL,

Secretary.

REPORT OF THE TREASURER.

Receipts.

Balance on hand, Feb. 21, 1812	$104.27
Received from membership dues	225.00
Received from initiation fees	46.00
Received from exchange on check	0.10
Received from sales of transactions	2.25
Total Receipts	$377.62

Expenditures.

Check to H. J. Webber, expenses as speaker at Bloomington	$ 57.31
Check to J. N. Hurty, expenses as speaker at Bloomington	13.80
To Worallo Whitney, expense of committee on High School courses	6.00
To J. T. Johnson, for ditto	6.80
To Lillian M. Hall, clerical work for F. C. Baker, Sec'y	20.10
To Frank C. Baker, Sec'y, postage and expenses	6.80
To John G. Coulter, for stenographer, Bloomington meeting	2.50
To Peterson and Kimball Co., Chicago, for printing for Bloomington meeting	46.50
To West Paper Co., Decatur, Ill:. Treas. statements and envelopes	3.25
To Springfield Transfer Co., for freight and transfer of Transactions	8.22
To Henry B. Ward, expenses as delegate to Iowa Academy Meeting	5.20
To Peterson and Kimball Co., Author's Reprints and Constitutions	28.00
To Peterson and Kimball Co., for printing programs, Bloomington meeting	12.00
To University of Chicago Press, letter-heads and envelopes for O. W. Caldwell, Sec'y	9.15
To John C. Hessler, Treas., postage, April 22, 1911, to Nov. 26, 1912	9.50
To University of Chicago Press, printing and addressing for O. W. Caldwell, Sec'y	17.94
To Hyde Park News Co., for printing circular letters, envelopes, and cards for Peoria meeting	12.25
Otis W. Caldwell, Sec'y, for printing, addressing, and postage bill of Jan. 22, 1913	23.48
Total Exenditures	$288.80

Summary.

Total Receipts	$377.62
Total Expenditures	288.80
Balance on hand, Feb. 21, 1913	$ 88.82

After examination of the Treasurer's books by the auditing Committee, consisting of C. E. Comstock, John M. Roberts, and George D. Fuller, the report was accepted as read.

Mr. W. L. Eikenberry, acting chairman of the Membership Committee, presented a list of forty-six names of those recommended by the committee for membership in the Academy. Upon motion, the report was unanimously adopted.

The president's address, entitled, "An Italian Academician" was then delivered by President Crew. Next came the symposium on, "The Science of Sanitation," which was presented in the following order:

1. **Birth and Death Registration.**—Frederick R. Green, American Medical Association, Chicago.
2. **The Influence of Shallow Wells on Health.**—Edward Bartow, Director Illinois Water Survey, Urbana.
3. **The Control of Stream Pollution.**—Paul Hansen, Illinois Water Survey, Urbana.
4. **Sanitary Aspect of the Milk Supply.**—P. G. Heinemann, Department of Bacteriology, University of Chicago.
5. **Housing in Relation to Health.**—Marion Talbot, Dean of Women, University of Chicago.

Time remained for the beginning of the program of "individual papers," and Dr. W. W. Atwood presented two papers. "Chicago Academy of Science—An Educational Force in the Community," and "A Celectial Sphere."

Sixty members of the Academy attended the banquet served in the dining hall of Bradley Institute at 6 P. M. The after-dinner talks were particularly pleasing and profitable. Each speaker gave a brief review of the most important discoveries made in his particular field of science during the previous year. If the purpose of the Academy is in part at least to give better distribution to scientific discoveries, and to extend the spirit of science this after dinner program was a decided success. Following is the list of speakers:

Botany, John M. Coulter, University of Chicago.
Zoology, Henry B. Ward, University of Illinois.
Entomology, Stephen A. Forbes, University of Illinois.
Geology, William S. Bayley, University of Illinois.
Physiological Chemistry, E. W. Washburn, University of Illinois.

FRIDAY, 8:15 P. M.

The evening address was given by Professor E. E. Barnard of the Yerkes Observatory, Williams Bay, Wisconsin. on the topic: "Some Late Results in Astronomical Photography." The lecture was remarkably instructive and interesting, and the thanks of the members to Professor Barnard were expressed on frequent occasions throughout the rest of the meeting.

SATURDAY, FEBRUARY 22, 9:00 A. M.

The reports of various committees were presented. The reports follow. Committees continued are—On Conservation, Calendar Reform, High School Leaflets, and Ecological Survey.

The following items of new business were transacted.

It was voted that the Committee which by vote of last year was called the "Committee on Legislation or Agreements for Setting Aside Lands for Conservation and Propagation of Common Wild Flowering Plants," should be known as the "Committee on Conservation."

It was voted, that during periods between meetings the Council shall be empowered to elect persons to membership in the Academy subject to approval at the next annual meeting of the Academy.

The following resolution endorsing birth and death registrations was presented, and it was voted to refer the resolution to a new committee on legislation with full power to act in furthering the intent of the resolution:

Whereas, The registration of births and deaths is a necessity in any modern civilized state, and

Whereas, The present law in effect in Illinois is inadequate and inefficient, be it

Resolved, That the Illinois Academy of Science desires to place on record its approval of all efforts to improve the conditions of vital statistical legislation in Illinois; and to request the members of the State Legislature to use all means to secure the passage of a law which will place Illinois in the Registration Area of the U. S. Census Bureau; and further to request the active co-operation of every member of the Academy.

A resolution designed to interest High Schools in taking membership in the Academy was presented and adopted, as follows:

Whereas, We believe that the Academy should make a special effort to bring the work of the Illinois Academy of Science in closer relations with the High Schools of the State, thereby aiding in the development of the various scientific courses, be it

Resolved, That the secretary be instructed to prepare suitable circulars and to mail the same before the close of the present school year, inviting each school to become a member of the Academy and to name some member of the faculty who shall represent the school in the Academy and to whom all communications may be sent.

The Academy was invited to hold its next meeting at Evanston, and at Charleston. The matter was referred to the council for decision.

The remainder of the session, until 1 P. M. was consumed with the presentation of papers according to the published list on the program. At the close of the presentation of papers the report of the nominating committee was given, as follows:

For President, Frank W. De Wolf, Urbana.
For Vice President, H. S. Pepoon, Chicago.
For Secretary, Edgar N. Transeau, Charleston.
For Treasurer, John C. Hessler, Decatur.
On motion this report was unanimously adopted.

The president appointed the following Committee on Legislation:

E. O. Jordan, Chicago.
A. R. Crook, Springfield.
U. S. Grant, Evanston.
W. S. Strode, Lewiston.
W. G. Bain, Springfield.
F. H. Funk, Bloomington.

(Owing to the resignation of Dr. Jordan, Dr. Crook was made Chairman.)

On motion the Academy adjourned.

REPORT OF THE COMMITTEE ON HIGH SCHOOL LEAFLETS.

When the committee made its report in 1912 at the Bloomington meeting it was expected that one of its members, who was in a position to do so, would, during the year following, give considerable attention to forwarding the plans

outlined in that report. No other member of the committee was in a position to give this matter the attention needed in order to have ready, prior to the 1913 meeting, a number of manuscripts for approval.

Unexpectedly, however, to himself as well as to the committee, the member who was to do this preliminary editorial work has been at work outside of the State almost continuously since the Bloomington meeting. In the coming year, however, the committee expects to be able to carry forward its work in the manner planned for the year just ended, and asks for continuance.

The following topics for leaflets are suggested:

(1) The mineral resources of Illinois.
(2) The soil of Illinois.
(3) The topography of Illinois.
(4) The geology of Illinois.
(5) The native mammals of Illinois.
(6) The birds of Illinois.
(7) The fish of Illinois.
(8) The insects of Illinois.
(9) The trees of Illinois.
(10) The Spring flowers of Illinois.
(11) The Summer flowers of Illinois.
(12) The Fall flowers of Illinois.
(13) The edible fungi of Illinois.
(14) Plant breeding in Illinois.

T. J. McCORMACK,
Chairman.

REPORT OF COMMITTEE ON APPLIED SCIENCE IN HIGH SCHOOLS.

Your committee regrets to report that it has been unable to complete the work it had expected to accomplish. At the last meeting of the Academy Mr. J. T. Johnson made a preliminary report on the condition of science teaching in agricultural high schools. It was expected that Mr. Johnson would extend his investigation during this year, but owing to his removal to Ohio he found himself unable to go on with his work for the committee. When this was ascertained by the chairman it was too late to arrange for someone else to take over the investigation.

Perhaps it will be wise to explain just what investigation the committee had in mind. It is well known that the study of agriculture is being introduced into the high schools in various states at a rapid rate and that many so-called agricul-

tural high schools are being established. We know that the conditions under which this is being done leave much to be desired. It has been difficult to find well qualified teachers, the text-books are still a mixture of various sciences labelled agriculture, and the arrangement of courses in the curriculum is more often a matter settled by convenience than by any scientific planning. To attempt to teach scientific agriculture in schools without carefully planned scientific course of study seems incongruous. Yet this is just what is being done in too many schools.

The service your committee had in mind is to bring together the practice of agricultural schools in various states with respect to courses of study and methods of teaching, in such a form that the best methods will be apparent and accessible for schools needing help in planning such courses. If the Academy desires, the work will be continued on these lines.

There is another movement in high school science that may furnish something for report in the coming year. We all know that at present, science in the high schools as in the colleges and universities is very distinctly divided into different departments of botany, zoology, physics, chemistry, physiography, etc. In the high schools these departments are taught in different years and one year's work is not related to any other year's work. To many this has seemed an unfortunate condition and one that does not tend to the advancement of science as a whole. Could not a consistent and practical plan be worked out through which there would be four years' work in science the work advancing step by step, gradually unfolding the elementary principles of all the departments of science as now taught. The difficulties in the way of accomplishing this are mostly administrative and, of course, prejudice. The advantages would seem to be very great, especially in time and energy saved, now lost through not making use of the past work of pupils in each year's advance. It is reported that one school will attempt to work out such a course. It is pioneer work and will require a faculty which can work in harmony. We hope the report is true.

WORRALLO WHITNEY,
Chairman.

MINORITY REPORT OF COMMITTEE ON CALENDAR REFORM.

A dozen years ago while in Mexico City, my attention was attracted as is that of nearly every tourist in that region to the old Aztec calendar stone with its 13 divisions designed centuries ago to represent 13 months of the year and the question arose in my mind as to the desirability of having 13 months of 28 days rather than 12 months of a varied number of days as we are at present doing.

Since that time I have been interested in various proposals made for reforming the calendar. I notice that as long ago as 1827, August Comte proposed a year with 13 months. Whether the suggestion came to him by the way of the Aztecs or not I do not know.

Similar proposals have been made at various times since then and various plans have been suggested as readers of Science, Nature, and other magazines have noticed within the last three or four years. Barton, Chamberlin, Clifford, Cohen, Cotsworth, Dabney, Dalziel, Flammarion, Grosclaude, Hesse, Hopkins, Kent, Patterson, Pearce, Reininghaus, Slocum, Super, Webb, and others have made various contributions to the discussion of the subject. (9) The question has been for some time agitated in Switzerland, Holland, Germany, France and England and bills have been introduced in various legislative bodies.

People, even members of this Academy, often ask what is the trouble with the present calendar. To be sure it is superior to the calendars of the Ancient Egyptians, Jews and Greeks, which accorded so imperfectly with the cycle of the seasons as to eventually transform the summer months to the winter season. While Julius Caesar and Pope Gregory greatly improved the calendar, still there are three or four particulars in which it is eminently unsatisfactory, such as in its disagreement with the astronomical seasons, its random length of months, its changing days of the week for the different days of the month and the consequent changing of holidays.

Among all the proposals which I have seen the so-called Geneva plan, set forth so admirably by Oberlin Smith, in the Popular Science Monthly for December, 1912, seems most desirable. (Parenthetically it may be said that the need for such change becomes possibly even more evident when such a careful writer as Mr. Smith in writing for such a magazine as the Popular Science Monthly makes what seems to me to be a mistake in calculating that his calendar could best begin

in 1918 when he should have said 1919 according to my calculations).

It has been proposed on several occasions that a "calendar betterment association" be formed. This is unnecessary since agencies already existing can be used for this purpose. I am sending out to one or two hundred of the leading scientific societies of the world, a letter asking if they have taken up the subject, if so with what conclusions and if not what they would think of the calendar enclosed in the letter. The membership of these societies runs from 100 to nearly 10,000 and thus there will be opportunity of ascertaining the thought of something more than 100,000 persons on this question. They are largely people who may be said to be employed to do original thinking and to lead in wise measures. The great mass of mankind are occupied in raising crops, in mining, in manufacturing, in transportation, in buying and selling, and in doing those things necessary for the material welfare of the race. But men of science and letters, educators and savants, are set aside by society to deal with all the various problems of less material or passing interest and I think such men should be in a position to give wise counsel today in this matter as they have in the past when they have proposed accurate and simple weights and measures.

If response can be obtained as I believe it can from the learned men of all continents, this Academy will be in a position to take up an active advocacy of a certain calendar. The learned organizations of the world can unite in giving recommendations to the legislators of various countries and there will be no need of waiting till 1956 as one writer proposes. I see no reason why the new calendar may not be begun in 1919.

On the following page is the calendar which to my mind is the best that has thus far been proposed.

*Calendar for 1919 and Ever After.

DAYS IN SEASONS	NAMES OF MONTH	DAYS	DATES OF SUNDAYS	LEAP YEAR
Winter 91	January	31	1, 8, 15, 22, 29	
	February	30	5, 12, 19, 26	91
	March	30	3, 10, 17, 24	
Spring 91	April	31	1, 8, 15, 22, 29	
	May	30	5, 12, 19, 26	91
	June	30	3, 10, 17, 24	
Leap Day				1
Summer 91	July	31	1, 8, 15, 22, 29	
	August	30	5, 12, 19, 26	91
	September	30	3, 10, 17, 24	
Autumn 91	October	31	1, 8, 15, 22, 29	
	November	30	5, 12, 19, 26	91
	December	30	3, 10, 17, 24	
Silvester		1		1
Total		365		366

December 1st, 1918, to be declared by edict to be December 10th to bring the winter solstice for Northern Hemisphere at December 31, 1918. At midnight of the day now called December 21, 1918, will begin the first hour of the first day of the first week of the first month of 1919.

No Sundays will be lost or gained.

In the United States holidays will be as follows: Lincoln's Birthday. Sunday, February 12; Washington's Birthday, Wednesday, February 22; Decoration Day, Thursday, May 30; Independence Day, Wednesday, July 4; Labor Day Monday, September 4; Columbus Day, Thursday, October 12; Election Day, Tuesday, November 7; Thanksgiving Day, Thursday, November 30; Christmas, Monday, December 25; Sylvester Evening, End of year.

In England, May Day, May 1st; Michaelmas, Friday, September 29.

In France, Saturday, July 14.

A. R. CROOK

*See article by Oberlin Smith, Pop. Sci. Monthly. Dec., 1912, pp. 582-590.

REPORT OF THE COMMITTEE ON AN ECOLOGICAL SURVEY.

The committee of the Academy on an ecological survey consists of all the members of the Academy known to us as active workers on ecological problems within our area. They are not numerous enough nor widely enough distributed to cover the entire state with a well-coordinated scheme of systematic investigation, but they are nevertheless obtaining important results in their several districts, all contributory to the general end. The districts which have been actively investigated are the Chicago Area; the Beach Area of northeastern Illinois; the counties of Jo Davies in the northwestern part and Fulton in the central part of the state; the Sand Prairies of the state, the Charleston Area, with extensions over eastern Illinois; and the Illinois River, with extensions to the Mississippi and the Ohio. A statistical survey of the bird life of the entire state, made four years ago, showing the numbers, distribution, and ecological relations of the species, is now being worked up for final publication.

The ecological relations of the crawfishes of Illinois have been studied and reported on by Miss N. M. Rietz, working under the direction of Dr. Adams, of the University of Illinois, in a paper based on an examination of about 2,000 specimens 1,600 of them from the collection of the State Laboratory of Natural History. The distribution and ecological relations of our crawfishes are given for each of the ten species found in the state, and the paper is illustrated by maps showing the Illinois distribution, and photographs of specimens and of characteristic habitats.

An important undertaking, not regional in character, is that of a general publication on ecological methods, with full lists of available papers especially helpful to the ecological worker. This work of Dr. Adams is now ready for publication.

Special features of the ecology of the Chicago Area have been actively investigated by Dr. H. S. Pepoon, of the Lake View High School; by Mr. Frank C. Baker, of the Chicago Academy of Sciences; and by Dr. V. E. Shelford, of the University of Chicago, assisted especially by Dr. W. C. Allee, Mr. G. D. Allen, and Miss Katherine Norcross. The vegetation of the beach area of northeastern Illinois has been studied by Mr. F. C. Gates, of the University of Illinois (now of the University of Michigan), and the results of his work have been published as a bulletin of the State Laboratory of Natural History. An associational study of the Illinois sand prairies, has been made by Mr. A. G. Vestal, under the direc-

tion of Dr. C. C. Adams, of this committee, and his paper on this subject is in the hands of the director of the State Laboratory for similar publication. The Charleston area is being studied, as heretofore, by Dr. E. N. Transeau and Mr. T. L. Hankinson, of the Eastern Illinois State Normal School. They, together with Dr. Adams, of the U. of Ill., are preparing a report upon a cooperative work done in this area three years ago. The plant ecology of the two northwestern counties mentioned is being studied by Dr. Pepoon; and the whole system of life of the Illinois River and the waters of its bottom-lands, together with that of the Des Plaines River and the sanitary canal, is being continuously studied by Dr. S. A. Forbes and Mr. R. E. Richardson, the latter in charge of field operations with headquarters at Havana.

Dr. Shelford reports the preparation of a general treatise on the ecology of the region about the head of Lake Michigan, soon to be published, in a semi-popular form, under the auspices of the Geographical Society of Chicago. Additional data has been presented in a series of papers printed in the Biological Bulletin, in which the following facts have been brought out: Fishes are sensitive to hydrographic conditions, and thus have definite arangements in comparable streams. (Streams flowing into Lake Michigan, between Glencoe and the Wisconsin line, are comparable in hydrographic conditions, their differences being due to differences in physiographic age. The head-waters of the oldest streams contain only species of fishes found in the smallest streams. Other species are arranged in the same order of succession in all the streams, those nearest the mouths of the largest streams being absent from the next smaller streams,) etc. A series of ponds at the head of Lake Michigan, arranged in the order of ecological age as shown by the amount of humus, the character of the vegetation, and the physiographic history, are shown to contain fishes which have a definite arrangement in these ponds (correlated with (a) the presence or absence of the kind of bottom prefered by the species in breeding; (b) with the amount of oxygen and carbon dioxide in solution; and (c) with the amount of humus and vegetation present. Fishes may be few where their food supply is most abundant; and the smaller food supply has been shown not to be due to the presence of the fishes).

A study of the different stages of forest development on sand has shown that the distribution of animals is correlated with the differences in the evaporating power of the air.

A study has been made of the seasonal succession in a temporary spring pond and on the low prairie vegetation of

the same area. Experimental data have also been collected showing the relations of animals to environmental factors, with a view to determining the most effective factors and the best indices of environmental conditions. A long series of experiments made by Dr. Shelford and Dr. Allee has shown that fishes are only slightly sensitive to lack of oxygen, but very sensitive to variations in carbon dioxide, the latter being thus the best index to the suitability of water for fishes. As fishes turn back when they encounter unsuitable water, conditions which would otherwise be fatal to them are of secondary importance. An arrangement of the species studied with reference to their avoidance of water containing five cubic centimeters of carbon dioxide per liter—that is, approximately ten parts per million,—corresponds to their arrangement with reference to the distribution of low oxigen and carbon dioxide in their habitats. Similiar results have been obtained with some of the invertebrates. Studies have also been made of the relation of several species of amphibians, insects, and arachnids to atmospheric conditions. Animals from moist woods hesitate or turn back when they come into air of high evaporating power—that is, air which is dry, or hot, or rapidly moving,—while regular residents of open, dry, sandy areas are found to be slightly positive to such air. Animals with similar integuments die in dry and rapidly moving air in the order of their degree of avoidance of such air. The animals of a habitat agree in respect to the degree of their avoidance of modified air, but not in the time of their survival in such air.

Dr. Pepoon is busily engaged on a "Flora of the Chicago Area," to include all plants within a radius of forty miles from the mouth of Chicago River,—that is, from Waukegan to the Indiana line, and westward to the crest of the Valparaiso morain—approximately to a line connecting Joilet, Aurora, and Elgin. This work will contain maps, photographs of typical ecological regions, discussion of plant associations, and an annoted list.

Mr. Baker's ecological investigation has taken the form of a paper on the life of post-glacical Lake Chicago, a work which has necessitated a correlation of the life of Chicago with that of all the lake stages from Lake Chicago to the Nipissing Great Lakes. The result strengthens a previously proposed theory of a post Glenwood low water stage, when the lake was about ten feet above the present datum, and also the presence of an extensive coniferous forest, principally of spruce. Several species, discovered in the Niagara Falls gravel

deposits, have been found also in the Chicago deposits of an earlier date, showing that the migration of life was principally by way of the Chicago outlet.

Dr. Pepoon is working on a survey of the plant ecology of Jo Daviess and Fulton counties in comparison with that of Cook county. With a list of 1,400 species for Cook, 950 for Jo Daviess, and 1,000 for Fulton, he finds about 50 per cent of the plants common to all three counties. Ten per cent of those of Jo Daviess, 13 per cent of the Fulton county species, and 20 per cent of those of Cook, are not found in the other two counties.

From a study of some 1,800 collection of the Algae of eastern Illinois made by Dr. Transeau during the last five years, he finds that our Algae may be divided into seven groups of markedly different periodic habit, and that, in opposition to the current view, they here fruit most abundantly during high-water stages. A list of the Algae of eastern Illinois, containing notes on 245 species and varieties, has been prepared, and will be submitted for publication in the Academy proceedings. Twelve of these species are undescribed, and 23 of them have not previously been collected in North America. It is an especially interesting fact that almost all of these new forms have been collected in remnants of four old prairie ponds, all threatened with extinction within a few years,—an illustration of the importance of prompt and rapid work on representative relics of the original system of ecological association still remaining in this state. The preparation of descriptions of of the plant associations of the Charleston area is progressing, but is not yet complete. The succession of such associations has been determined, a list of the prairie plants is nearly finished, and a list of the forest plants is well under way.

Mr. Hankinson is still working upon the ecological biology of the streams of his area, and has also made many notes, collections, and photographs illustrating the life of the woodlands and of the open fields. The invertebrates of his collections are being distributed for determination, and his data relating to fishes are being made ready for publication.

The work of the natural history survey of the state, is in progress under the State Laboratory of Natural History, has been limited during the past year to further studies of the biological system of the Illinois River as affected by seasonal, hydrographic, and chemical conditions—but especially by contamination factors introduced by way of the sanitary canal of the Chicago district; and to the preparation of a final report on the statistical survey of the bird life of the state already referred to.

Only a few of the more significant results of this river survey can be mentioned here. Daily observations on the breeding habits of Illinois fishes, and parallel aquarium studies, have given us a considerable body of new information of importance to fish culture and to the maintenance and improvement of our fisheries. Two papers are in press. Comparisons of the yield of plankton at Havana, on the middle Illinois, for three years preceding, and a year following the opening of the Chicago Drainage Canal, show a greatly increased average yield per cubic meter in the river itself and in certain classes of lakes, and an enormous increase in the total product of these waters, to be connected with their increased volume and the greater average area consequently covered by them. We find the Illinois at Havana about two and a half feet higher than before the opening of the canal, the plankton yield of the stream itself approximately twice as great to the unit of volume, that of Quiver Lake about three times as great, and that of Thompson's Lake practically unchanged. The plankton product of the river reaches its minimum, for the warmer part of the year, when continuous low water isolates its bottom land lakes for a long time, these being reservoirs from which the plankton of the stream is continuously replenished.

The effects of sewage contamination upon the system of river life become extreme during long-continued hot weather coinciding with unusually low river levels. Under such conditions as prevailed in July and August, 1911, the upper twenty-six miles of the Illinois, (from the mouh of the Kankakee to the dam at Marseilles,) becomes virtually a septic tank, with oxygen ratios averaging one third or less of saturation, at a time when the waters of the Kankakee just above, are supersaturated; with carbon dioxide as high as 11 parts per million, while in the Kankakee it ranged from 2 parts down to zero; and with the gases of the bottom sediments indistinguishable in composition and proportions from those of the sludge of a septic tank. Fishes were altogether absent from this part of the stream at this time, and the main content of our collections consisted of foul-water organisms mingled with the more resistant species coming in from Lake Michigan and from the Kankakee—the latter rapidly diminishing in numbers, however, as they were carried down stream. The only fish mortality noticed which was due to sewage was in the Sanitary canal itself, and in the highly contaminated Des Plaines. Fishes simply withdrew from the more polluted waters of the Illinois into normal or less contaminated tributaries. A considerable overturn, both chemical and biological, was made by a 12 to 14-foot fall of the stream over the Mar-

seilles dam, and a consequent thorough aeration of the water, the dissolved oxygen in the stream a mile below the dam being about two and a half times that immediately above the dam, and the carbon dioxide being at the same time reduced by 21 per cent. In the eighty-three miles of the river between Morris and Chillicothe, the dissolved oxygen of the water increased 183 per cent, and the carbon dioxide diminished 22 per cent.

A summary of the parallel changes in the biology of the stream is not possible at this time. It must be said, however, that fishes appeared in our collections, even under midsummer conditions, in gradually increasing variety as we went down the stream, from the Marseilles dam, until, at Chillicothe, we had a fair representation of the common fish life of the river. At high-water levels, and in cooler weather, fishes returned, indeed, to the uppermost section of the river, although they could be found there in only scanty numbers and in comparatively small variety. Attempts were made to correlate species and numbers of organisms obtained in the river collections with different degrees of pollution or contamination, in a way to make a classified species list available as an index to such degrees. The determination of these recent aquatic collections is still in progress, and the completion of our report will require many weeks of additional work.

Your committee feel that this showing of productive investigation is not at all to the discredit of the ecologists of the Academy; but we are fully aware that most of us are still working, each on his own problems in his own chosen field, with no marked affiliation with the other investigators. We are of the opinion that it is now particularly important that efforts should be made to interest as many capable observers and collectors as possible in a study of the remnants of the prairie life of the state, now rapidly disappearing forever. Preliminary to this we need as full knowledge as can now be obtained of the existence and location of tracts or patches of prairie turf—outside the so-called sand prairies of the state, which have already been very well studied, and we appeal particularly to members of the Academy to advise us on this point, in order that we may, without further delay, take such measures as are possible for a careful study of the leading types of our prairie remnants in the principal sections of the state.

Respectfully submitted.

S. A. FORBES,
Chairman.

The President's Address.

AN ITALIAN ACADEMICIAN.

HENRY CREW

The mission of an academy of science is a function of the age in which it flourishes. The ancient academies accomplished a work now performed by the universities. The Italian academies of the Renaissance, variously estimated at from 500 to 700 in number, represented different purposes almost as numerous as the institutions themselves. But in general they were literary and scientific clans; they belonged to a period when learning was the possession of the few, to a period when one might still take all science for his domain.

The modern academy is, as a rule, closely allied with the sovereign power of some state, whose interests are promoted by it, consciously and unconsciously, in a variety of ways. The service which it renders is sometimes political, sometimes literary, sometimes scientific, sometimes social. But, so far as I can see, they have, in common, these two ends, namely, the encouragement of the individual and service to the community.

The triple purpose of the Illinois State Academy of Science is clearly stated in the second article of its constitution as being "the promotion of scientific research, the diffusion of scientific knowledge and of the scientific spirit, and the unification of the scientific interests of the state"; just how this object can best be secured is the interesting subject of an after-dinner discussion this evening.

I leave this problem, therefore, with the single remark that the importance of cultivating individual initiative and of handing on to the community the best there is in the achievements of science is not likely to be overestimated.

Symonds(1) points out that Athens and Florence owed their wonderful intellectual, artistic and literary success mainly to the fact that they nourished the individuality of their citizens; while Sparta and Venice, comparatively barren of permanent results, illustrate the lack of such encouragement.

I now invite your attention to one of the earliest members of the venerable and thankworthy Academy of the Lyncei, a man who represents in the highest degree the individuality then cultivated in Tuscany, a man whose impress upon his students was so deep that shortly after his death they united to form one of the most productive and justly celebrated of all the Italian academies,(2) a man whose written works fill twenty splendid quarto volumes,(3) a man who in his efforts to put before the people the best science of his

times, endured opposition, criticism, disgrace and social ostracism throughout most of his thinking life. I refer to Galileo. But I shall speak only of what he did in physics, because I believe this phase of his work is too little known.

What Galileo saw through telescopes of his own make, though not of his own invention, is so familiar that possibly a majority of intelligent men think of him mainly as an astronomer. The spots on the sun, the mountains on the moon, the satellites of Jupiter, the phases of Venus, the "triple character" of Saturn, the solar rotation period, lunar libration and earth-shine are some of the celestial phenomena associated with the name of Galileo. These and his brilliant defense of the Copernican system are responsible for the impression that his accomplishments are chiefly astronomical.

To another large group of men he stands mainly for liberty, intellectual, social and religious. These men classify nim with Giordano Bruno and De Dominis and Campanella who also had some experience with the cardinals of the Inquisition. For them Galileo is the man who dared to differ with Aristotle, the man who brushed aside the mists of philosophy, the man who banished church traditions from his thinking while he calmly pursued his search after unity in the physical universe.(4) It is doubtless his splendid stand for spiritual freedom which leads Goethe(5) in his historical sketch of optics to say

> Even though he never seriously studied the subject of color, I must at least adorn my page with his name.

But there is still a third group of men to whom the great Italian appeals most strongly because he has given them a new method of working and thinking, a new viewpoint, a new *apercu*. To put this contribution in its proper perspective is not an easy matter; we are too near it and too familiar with it. If, however, one considers the time interval between Archimedes and Kelvin he can not fail to notice a sharp discontinuity in the progress of physics occurring about the beginning of the seventeenth century. Just how commerce and industry led up to, and prepared the way, for this step is the subject of a most interest chapter by a member of this academy, Professor Mann.(6)

Without underestimating the contribution of Pappus or Tartaglia or Benedetti or Stevinus or Leonardo da Vinci, to mechanics; and without denying the important role of statics in architecture and in other structural work one may, I believe, fairly say that the years which intervene between Archimedes and Galileo are practically barren of progress in physics.

It is true, indeed, that during this interval a large number of isolated physical facts had been discovered; indeed there is scarcely a chapter in physics in which some advance of this type can not be mentioned; but, during all this while, nothing in the way of development is seen; individual discoveries remain isolated; they do not bear fruit; speculation and guessing were still employed where we use observation and measurement and computation. Leonardo da Vinci likens a scientific conquest to a military victory in which theory is the field marshal; experimental facts, the soldiers. The philosophers who preceded Galileo had, in the main, been trying to fight battles without soldiers. The only possible exceptions to this statement are Roger Bacon, Leonardo da Vinci, Stevinus and Gilbert. They had measured some mechanical quantities—a few of them—masses and stresses—such as could be obtained by means of a steel-yard and a measuring stick; but they were still in the domain of statics. Now from a geometrical, esthetic or even utilitarian standpoint, it is difficult to imagine any finer subject than graphical statics; and yet when we regard the progress of physics, statics is to dynamics somewhat as osteology is to physiology, a veritable valley of dry bones. The live part of mechanics is kinetics, the study of masses which are in motion, the consideration of bodies which are changing their velocities, currents of water, oscillating magnets, vibrating strings, rotating wheels, electric motors, heat engines, electromagnetic waves, and X-rays. These are the problems over which men lose sleep; these are the questions which compel the interest of the physicist; these are the subjects whose mastery confers power upon the engineer. The one confessed aim of physical science is, indeed, to describe the motion of bodies in the simplest possible manner. Indeed it is only by the aid of this modern science of the energy of motion that any of the ancient mechanical doctrines—such as the atomic theory of Democritus—have acquired validity; it is this same science which has rendered the heliocentric theory of Copernicus not merely "a plausible view" but the one possible view.

We pass now to a more definite question, namely, what contribution did "our Academician" make to the solution of problems of this type, to the science which now goes by the name of physics? To answer briefly and baldly, he instituted the method and set into motion the machinery by which practically all these problems have been solved, in so far as they have been solved at all. But lest I give the false impression that Galileo was the ancester of all the physical sciences. I hasten to a more detailed answer to the query, What did Galileo?

1. First, no greater mistake could be made than to suppose that Galileo was the first man to differ with Aristotle; the academy of Cosena, having opposition to the peripatetic philosophy as its avowed purpose, was established at Naples about the time when Galileo was born; but he was the first man to offer experimental evidence against the conclusions of Aristotle; and in so doing he established what we now call the experimental method. He was not handing on an opinion which some "dusty minded professor" had inherited from an ancestor of the same type.

Only two methods of investigation were known to the ancients, the philosophical and the mathematical; to these Galileo added a third, the experimental. The philosophical method consisted in assuming certain general principals and trying to find in them an a priori explanation of the universe. Briefly described, the attempt was to stare nature out of countenance. Failure was inevitable, not for want of intellectual acumen, but because, as every one in this assembly knows, it sometimes requires a lifetime of effort to explain a single detail. Witness almost any chapter in Darwin's "Origin of Species." Details must be mastered before one can pass to general principles.

The mathematical method consisted only in applying geometry to certain well known areas, volumes and angles, especially to those angles observed in the sky, but always with the idea of describing the known rather than discovering the unknown: the mathematicians do not appear to have put any deliberate questions to nature; or as Rowland said:

> A mathematical investigation always obeys the law of the conservation of knowledge: we never get out more from it than we put in. The knowledge may be changed in form, it may be clearer and more exactly stated; but the total amount of the knowledge of nature given out by the investigation is the same as we started with.

The experimental method, established mainly by Galileo, not only combines the observations of the philosophers with the measurements of the mathematicians, but adds deliberate experiment with a distinct purpose to interrogate nature concerning some detail of her behavior. Generalizations based upon these details the experimenter reserves for a later date. The high regard in which Galileo held experimental facts is reflected in the following from a letter (7) to the Grand Duchess Christina, dated 1615. He says:

> I would entreat these wise and prudent fathers to consired diligently the difference between opinionative and demonstrative doctrines, to the end that

> they may assure themselves that it is not in the power of professors of demonstrative sciences to change their opinions at pleasure.

Or witness the following paragraph from the "Saggiatore"(9) as illustrating the great weight which Galileo attached to experimental evidence. He says

> We examine witnesses in things which are doubtful, past, and not permanent, but not in things which are done in our presence.
>
> If discussing a difficult problem were like carrying a weight, then since several horses will carry more sacks of corn than one alone, I would agree that many reasoners avail more than one; but discoursing is like coursing, and not like carrying; and one barb by himself will run faster than a thousand Friesland horses.

In all his thinking nothing is exempt from experiment. Astronomy even, in his hands, ceases to be a purely observational science; for when he wishes to discover whether the bright portions of the moon's surface are rough or smooth, he sets up two surfaces, one rough and one smooth; then illuminates them with Italian sunlight. Desiring to learn at what rate falling bodies gain speed, he devises a time measuring machine, invents a method of "diluting gravity" and actually measures the rate at which speed is gained. His discussions begin and end with experiment—a method so familiar to us that we forget how recent and powerful it is.

His two great dialogues—one dealing with astronomy, the other with mechanics—abound in experiments—most of them apt and clever. Leonardo da Vinci advocates experiment: Galileo uses experiment.

2. The second great achievement of Galileo was his seizure upon momentum as the fundamental quantity in the science of mechanics, and his demonstration that velocity is a factor in momentum. Galileo was by no means the first to study and discuss kinematical problems.

Benedetti (1530-1590), one of the many distinguished alumni of the University of Padua, had not only expressed dissatisfaction with the artificial distinction between "violent" and "natural" motions, but had gone farther and had paved the way for mechanics and the differential calculus by recognizing the fact of continuous variation in motion: Benedetti (10) had in particular studied oscillatory motion and had shown that such a motion is continuous even when the vibrating particle is at rest at the end of its path. He had in fact introduced the modern idea of continuous variation. But none of the predecessors of Galileo had, so far as I have been

able to discover, pushed their study of moving bodies beyond the mere consideration of change of position. None of them had recognized the inertia of the moving body as a fundamental—perhaps the fundamental-fact of mechanics. Princes and paupers, for ages, had stumped their toes against bricks and stones: they were doubtless quite as familiar as we with the mere fact of inertia. But to Galileo it was a cardinal fact, because he was the first to see that the future history of a body depends upon its possession of inertia. To him the importance of a motion is, in general, measured by the inertia involved, or as was then said—the weight involved. Hence he assigned to the product of the weight and velocity of a body the name "momentum," which is merely the Latin word for importance; as a synonym he sometimes uses the word impetus, thus emphasizing the impetuosity of motion.

But Galileo never got beyond the point where he measured inertia by weight, as, indeed, engineers still do—all, at least, except electrical engineers. The invention of the idea of mass was reserved for Newton. Even Huygens,(10) who first mastered the idea of centrifugal force, never got beyond the point where he measured centrifugal forces in terms of weight, thus avoiding the conception of mass in all his work.

Those who wish to see just how clearly Galileo conceived that the future behavior of a body is connected with its inertia should read those propositions in his "Mechanics"(11) in which he calculates the path of a projectile by assuming that the horizontal speed of a shot, after it has left the muzzle of a gun, continues to be uniform. His repeated use of this principle makes it perfectly clear that he discovered what we now call—and perhaps properly call—Newton's first law of motion. Galileo failed to generalize it by extending it to all bodies whether subject to the earth's gravitation or not. This Newton did because he had acquired the new concept of mass—that constant property which never deserts a body in any position or condition.

3. The next great step which Galileo made was the discovery of the constant factor in the motion of falling bodies. One of his earliest experiments, performed while still a young man at the University of Pisa, was to allow a bronz ball to roll down a perfectly prepared inclined plane, an experiment from which he cleverly inferred that while the position and speed of the ball were changing, the time-rate at which it gained momentum remained constant. It was with reference to these particular experiments that Goethe remarked "dem Genie, ein Fall fur tausend gelte." The experiment is completed by showing how one can compute the momentum (or

speed) of a body after it has been falling for any given time or through any given distance. In all these computations, the unit of momentum employed is that which a body acquires in falling freely through an arbitrarily selected unit of distance.

As illustrating how tenaciouly he clings to the idea of momentum, witness the following clear, exact and thoroughly modern definition dating from the year 1604: (12)

> I call a motion uniformly accelerated when starting from rest its momentum, or degree of speed, increases directly as the time, measured from the beginning of the motion.

Observe that we have here, without any mention of the word, precisely the dynamical idea which we today use under the name of a "constant force." There is, indeed, no necessity for the name; for Galileo attempts nothing more than to discover how the momentum of a body changes owing to the presence of another body such as the earth in the neighborhood (action at a distance) or owing to contact with an elastic body such as the hot gases of exploding gunpowder in the barrel of a gun (action through a medium). Later generations had not yet beclouded the idea of force with "tendencies to motion"; they had not yet identified it with that vastly more complex "muscular sensation"; they had not yet made it over in the form of a "man"; they had not yet named it an "agent"; they had not yet identified it with a state of stress or strain which one elastic body exhibits when held permanently at rest by another elastic body; still less had there been any attempt to convince people—principally high school lads and college students—that all these various things are one and the same, since, forsooth, at various times we call them by one name, "force." Some of Galileo's most worthy successors, such as Clifford,(13) Poincare(14) and Hertz, have pointed out our inconsistent definitions of force, and have advocated in the most outspoken manner, a return to the simple methods of this Italian academician.

The best known of all his experiments is, of course, that is which he proves that the time of fall is independent of weight, an experiment which completes to a first approximation the laws of falling bodies practically as we have them today. He accomplishes a second approximation by eliminating the bouyant force of the medium. He is prevented from making ing a third approximation only because he meets the barrier of viscosity, a barrier which still renders impossible the solution of any but a few simple cases in fluid motion.

The one remaining fundamental phenomenon of falling bodies, is that the acceleration of gravity is independent of

the substance of which the falling body is composed. This Galileo(15) proved by swinging, side by side, two pendulums, having bobs of lead and cork, respectively. When the suspension fibers had equal lengths and the pendulums swung through equal amplitudes, they had equal velocities at each point of their path. It is difficult to find in Newton's hollow pendulum experiment much more than a second approximation in which he eliminates the air resistance from this experiment of Galileo.

4. The fourth advance which we owe to Galileo is the observation that the momentum communicated to a body in one direction does not alter its momentum in a direction at right angles. This independence of components of momenta, now known as Newton's second law of motion, was in the hands of Galileo no mere philosophical theorem, no vague guess, but a practical rule of action to be empolyed in mechanical operations. It is by compounding a uniform horizontal velocity with an accelerated vertical velocity that he proves, for the first time, that the path of a projectile is a parabola. It was by means of this principle that he prepared a range-table for gunners. The fact is then that Galileo discovered and employed the first two of Newton's laws essentially as we use them today.

It requires more than sheer strength to climb a difficult mountain peak; one must start in on the right trail. More than mere intellectual ability is needed to make an important discovery in physical science; one must start in with the correct viewpoint. This viewpoint is precisely what Aristotle lacked and exactly what Galileo possessed. It is Gomperz,(16) the distinguished historian of Greek thought, who says:

> The physical doctrines of Aristotle are a disappointing chapter in the history of science. They display to us an eminent mind wrestling with problems to which it is in no wise equal.

5. As a minor achievement of Galileo allow me to mention some discoveries to which he blazed a part of the road.

In a letter to a friend he says he had spent more years in the study of philosophy than weeks in mathematics. It is therefore, extraordinarily surprising to find set forth in his "Dialogues on Motion"(17) all the detailed facts and ideas which are involved in the modern definition of an infinite quantity developed by Boltzano, Cantor, and Dedekind, viz., an assemblage containing a part which may be put into one-to-one correspondence with the whole.

Again he paves the way, in a very distinct manner, for the differential calculus, in pointing out that the definitions(18) of constant velocity and constant acceleration hold only when

the times considered are "all whatsoever." If, therefore, one wishes to employ these definitions in the discussion of variable motion he must take his time intervals indefinitely small.

The invention of the well-known thermoscope which Galileo employed in his lectures at Padua also belongs here; for while it is not a true thermometer it doubtless led immediately to those exquisite sealed instruments shortly afterwards constructed by the Accademia del Cimento and still preserved in the Tribuna di Galileo at Florence. The theory of "dimensions," first stated by Fourier, was led up to in the First Day of the Dialogues on Motion.

The principle employed in his measurement of the density of air(19) is one which is not only faultless in principle but one which makes it plainly evident that Galileo had properly conceived that idea of atmospheric pressure which, in the hands of two of his students, led to the invention of the barometer, and, in the hands of von Guericke, to the air pump. Torricelli knew well the Dialogues on Motion.

6. Finally, Galileo was an inspiring teacher and built up at Padua a great school of physics. Many of his students lodged under his own roof; helped him in his own garden; ate at his own table. He had his own workshop and employed his own mechanicians. Generous with his time, his energy and his money, master of a fine literary style, endowed with a keen sense of humor, familiar with the best that had been said and thought in the world, standing in the front rank of investigators, is it any wonder that young men of talent hastened to Padua from all parts of Europe? Could any higher compliment he paid to a teacher than the devotion exhibited by the youthful Viviani, a lad in his 'teens, for his master already some seventy years old and a "Prisoner in Arcetri?" If deferred payments of the kind that teachers mostly depend upor ever get as far as the next world, surely this courageous spirit harried throughout his long life by poverty, ill-health and the censorship of the church, must have been gratified by the the work of the Accademia del Cimento which was, with the exception of a single man, composed entirely of his students. Mechanics was the one subject to which he was devoted constantly and persistently throughout his life; it was the subject of his earliest investigation when a young man at Pisa; the subject upon which he lectured when in his prime at Padua; the subject of his latest and most mature reflection at Arcetri. His most important contribution to dynamics was published in the seventy-third year of his age.

If, in conclusion, I were asked to summarize in a single sentence the principal contributions to the science of physics,

I should mention the two following facts: (1) That knowledge of physical phenomena which is to receive "impersonal verification" and become useful, must be obtained mainly by experiment adapted to ask of nature some particular question. (2) That momentum considered as a function of time and position is a fundamental dynamical concept; or, in other words, to discover how the change of momentum of any body is connected with the physical circumstances in which the body is placed, is the one great problem of dynamics.

But perhaps, after all, his most important contributions lie outside of physics. Indeed Galileo has not yet shot his last arrow. For his life still teaches us that nothing is so because any man says it is so. His example still shows how experiment can rob a man of all arrogance of opinion, how familiarity with unsolved problems can give a man genuine humility, and how, on the other hand, the possession of clear experimental evidence arms him with sure confidence.

Critics tell us that Florence, during the Renaissance, shown with a borrowed light—a light reflected from Athens. But I venture to think that those who will take the pains to look over the pages of Galileo will find them self-luminous.

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(1) "Renaissance in Italy," Vol. I., p. 234.

(2) Accademia del Cimento, founded in 1657; disbanded in 1667.

(3) Edited by the scholarly care of Professor Favaro, of the University of Padua, and published by the Italian government, 1890-1909. Referred to hereafter as "Nat. Ed."

(4) For a masterly presentation of this phase of Galileo's work, see Dr. Charles J. Little's article in the Methodist Review, Vol. 88, pp. 204-218, 1906.

(5) Gothe, "Farben-lehre Historiche Theil," art. Galileo.

(6) Mann, "Teaching of Physics," pp. 107-110 (Macmillan, 1912).

(7) "Nat. Ed.," Vol. 5, pp. 326. Translated in Fahie's "Galileo," p. 187.

(8) "Nat. Ed.," Vol. 6, p. 340. Translated in Fahie's "Galileo,"

(9) Lasswitz, "Atomistick," Bd.2, pp. 14-23, gives a good description of Benedetti's work.

(10) Huygens, "Horologium Oscillatorium," Part V., Prop. 13; or Hobart, "School Science and Mathematics," Vol. 11, p. 692 (1911), for translation of Huygens' paper.

(11) Galileo, "Dialogues on Motion," Fourth Day, Problem I. et seq.

(12) "Nat. Ed.," Vol. II., p. 166.

(13) Clifford, Nature, Vol. 22, p. 122 (1880).

(14) Poincare, lecture before the Wissenschaftlich Verin in Berlin, p. 116 (Teubner, 1912).

(15) "Nat. Ed.," Vol. 8, pp. 128-130, First Day, translated into German by von Oettinger, Ostwad's Wiss. Klassiker, No. 11, p. 76.

(16) "Greek Thinkers," Vol. 4, p. 108, Berry's translation.

(17) First Day, "Nat. Ed.," Vol. 8, p. 78.

(18) Third Day, "Nat. Ed.," Vol. 8, p. 191.

(19) "Nat. Ed.," Vol. 8, p. 124, First Day.

SYMPOSIUM ON THE SCIENCE OF SANITATION

WHY SHOULD BIRTHS AND DEATHS BE REGISTERED IN ILLINOIS?

FREDERICK R. GREEN

The basis of all knowledge is carefully observed and accurately recorded facts. If this is true in biology, chemistry, geology or astronomy, it is even more so in the two most important events in the life history of every human being, birth and death. It is indeed strange that our laws provide for records of real estate transactions, transfers of property, patents, inventions and copyrights of books; that we carefully preserve the transactions of all kinds of business, scientific and pleasure organizations, and that those interested have made the most minute records regarding animals and plants, insects and micro-organisms, and yet, in forty out of the forty-eight states that compose this nation, no provision exists for recording the birth of a new life and the appearance on earth of a new individual, while in twelve states, a human being can die and be buried, without any record of the event being made or preserved. This singular disregard for authenticated and attested records of birth and death is one of the evidences of our newness as a nation, and of our defective social organization. In the older civilizations of Europe, positive proof of personal identity, from the time of birth until death, is regarded as of the utmost importance, and is essential to participation in any of the activities of life In Germany, for instance, the child cannot enter the public school, the gymnasium or the university, without a copy of his birth certificate, to show who he is, who are his parents and when and where he was born. If he does not follow the path of higher education, he cannot secure any employment or be apprenticed to any trade, without first showing this birth certificate. If he desires to leave home and go to another country, he cannot secure a passport to cross the frontier without establishing his identity. If he desires to marry, a copy of his birth certificate and that of his future wife

must be presented before a marriage license will be issued. If he is a candidate for any public office or civil appointment, he must produce his birth certificate as an evidence of identity. Educated Europeans look with amazement on this vast country and its rapidly growing population, which has continued to multiply, either by immigration or by natural increase, for nearly 150 years, without making, until a few years ago, any intelligent effort to record the birth and death of its citizens. The family Bible, with its carelessly kept and incomplete record, often destroyed by fire or disappearing in the course of time, has been the only record which has been made of the appearance and disappearance of millions of our people. As a result, we are practically dependent for information regarding our immediate ancestors on records which are entirely untrustworthy, or on equally doubtful family traditions, handed down by word of mouth from generation to generation. This audience today, is probably as typically American as one could secure. It is probable that at least 90 per cent. of the immediate ancestry of those in this room were men and women of more than average education, and, consequently, more interested than the ordinary person, in questions of descent and heredity. Yet I question whether 5 per cent. of us could give the names, the place and date of the birth and the place and time of death of our immediate ancestors in the third generation, while probably not as many of us could give the names of the brothers and sisters of our grandfathers and grandmothers, who are only two generations removed from us. A farmer who did not keep a better record of his stock, would be regarded as a very careless breeder. Those interested in race-horses, bull terriers, angora cats or pouter pigeons, probably know a great deal more about the genealogy and ancestry of their pets than they do about that of their own children. Each of us has two parents, four grand-parents, and eight great-grand-parents. How many of us could, either from present knowledge or after any amount of careful investigation, produce positive proof of the identity of our eight immediate ancestors in the third generation or of our descent from them? How many of us today could produce positive legal evidence of our direct connection with our four grand-parents? Let us bring it even closer and make it more personal. How many persons are there at present within the sound of my voice, who could, if necessary, produce legal documentary evidence of the place and date of their own birth and of their own parentage? Those whose parents are still living could avail themselves of this evidence, but aside from this means, how many of us could produce any positive proof, that we were born at the

time and place, and of the parentage that we have always believed ourselves to be?

It is a singular thing that the American people, coming as we do from various European nationalities, all of whom have some form of birth registration, and most of whom are proud of their immediate ancestry, should have almost completely disregarded, until recently, the importance of registering births and deaths. In a few of the older New England states, this subject has long been regulated by laws. New Hampshire, Connecticut, Rhode Island, New York, and Massachusetts have had some form of registration since about 1850. Kentucky, South Carolina and Virginia had similar laws at that time, but the disorganization during and immediately following the Civil war put a stop to such efforts, and it is only in recent years that any interest on this subject has been aroused in the South. In 1880, registration of deaths was only enforced on 17 per cent. of the population of the United States, and as late as 1906, less than 48 per cent. of the population of the entire country was subject to any efforts to register deaths of human beings. In the remaining 52 per cent. no more legal or official recognition was made of the death of a human being than was made in the case of a dog, or a cat, or a horse. They died and were buried, and that was all there was to it. No record remained to show when or where they died, what was the cause of their death or where their body was deposited, except such personal records as might be made by immediate relatives.

This situation, and the lack of reliable records has frequently been discussed in medical and scientific bodies. As far back as 1848, the year following the organization of the American Medical Association, a standing committee on registration of births, deaths and marriages, reported, urging the adoption of proper laws by all of the states. In the transaction of the American Medical Association, the American Public Health Association, the Conference of State and Provincial Boards of Health, and similar organizations, will be found frequent references to this subject, yet in 1880, after thirty years of effort, deaths were recorded in only 17 per cent. of the population, in 1906 in only 48.5 per cent. and in 1912, there were still nearly 40 per cent. of the population without any registration of deaths, while today, forty out of forty-eight states make no record of births.

In 1906, at the annual Conference on Legislation of the American Medical Association, a committee was appointed to draft a model bill for introduction into state legislatures. This committee reported in December of 1907, presenting the draft of a bill suitable for adoption by individual states pro-

viding for the registration of births and deaths, including the uniform death certificate, and introducing the international nomenclature of diseases. This bill has since been endorsed by the American Medical Association and its Section on Preventive Medicine and Public Health by the Bureau of Census of the United States Government, by the American Public Health Association, the American Statistical Association, the American Association for the Study and Prevention of Infant Mortality, the National Conservation Congress, the American Federation of Labor, the General Federation of Women's Clubs, the Commission on Uniform Laws of the American Bar Association, and a large number of other organizations interested in improving public health conditions. This bill is drafted in harmony with the experience of public health officers, statisticians, sanitarians, lawyers, judges, administrators and all others whose views and co-operation could be secured. Since it was drafted in 1906, the registration area for deaths has increased from 40 per cent. to 63.1 per cent.

So much for the history for this movement. Let us now consider briefly, some practical reasons why every citizen should be interested in securing adequate birth and death registration for Illinois. On account of the general interest in this subject on the part of physicians, and because birth and death certificates are necessarily signed by them, the public has assumed that this is a question which is of interest to physicians alone. When the public, and especially the members of the state legislatures see physicians, both individually and as representatives of medical organizations, appear before legislative committees in different states, year after year, they naturally assume that birth and death registration is a subject in which physicians have some selfish, personal interest, else they would not devote so much time and effort to endeavoring to secure laws on this subject. Yet, the fact is, that with the exception of their interest as citizens, physicians have probably less interest in endeavoring to secure laws on this subject than almost any other class of citizens. It is no special advantage to physicians, as a class or as individuals, to know the exact number of births and deaths, while the greater part of the labor of filling out birth and death certificates falls on the family doctor. The fact that this work is generally done without compensation, and that the general feeling among physicians and in medical organizations is against compensation for such work, only makes the situation all the more striking.

Why have physicians and medical organizations interested themselves in securing the registration of births and deaths, and what reasons are there, aside from sentimental

ones, why the state should provide the necessary machinery for registering these events? The reason why the physician is interested, is because birth and death registration is, as it has aptly been styled, "the book-keeping of humanity." It is only by carefully recording all births, by observing the number and percentage of births and deaths over a large area with a large population for a long period of time, that any accurate figures can be secured regarding the average birth or death rate per 1,000 or per 10,000 of population, the relative birth and death rate in different localities, races and periods of time, the relative death rate in different periods of life, the average duration of life, and what insurance men call the "expectation of life", the relative proportion of deaths occurring from different causes and the relative frequency of disease. In short, the only way by which any accurate figures can be secured, on which can be based any statements regarding vital facts, is the systematic registration of births and deaths.

It is, accordingly, only in a state or a community in whch births and deaths are carefully observed and recorded, and in which the recording system and the nomenclature used are uniform with those of other states and countries that the community can learn whether it is gaining or losing in population, whether the birth rate is increasing or decreasing, whether the death rate, either as a whole, or from some single cause, is increasing or not, whether the efforts to improve sanitary conditions are successful or not, and what is the relative value of different methods. Just as a business man who kept no books would be unable to determine his financial condition, or whether he was making or losing money, so the health officer who is without carefully recorded vital statistics is equally at a loss. General impressions are notoriously untrustworthy. A community may believe that is is unusually healthy, yet a careful record of deaths may show that the death rate is fifty, seventy-five or even one hundred per cent. in excess of the normal, and this from thoroughly preventable causes. Dr. W. S. Rankin, Secretary of the North Carolina State Board of Health, says: "Applied vital statistics is the most essential and powerful remedy for the improvement of the health or social organizations for bringing about sanitary reforms, for preventing diseases, for postponing death, and for adding years to the duration of the average life that we possess." Just as accurate book-keeping with carefully drawn balance sheets and an exhaustive analysis of expenses will enable the merchant to save money, so carefully kept records of mortality will produce longer life. Dr. Rankin illustrates

this by giving an instance of a city of 20,000 people in North Carolina. On his arrival in the city, he called up five representative citizens on the telephone, and asked them their opinions as to the health of their city. One was a college president, one was a city official, one a practicing physician, one was a banker and the other a leading merchant. All unhesitatingly answered that the health of the city was good. They were then asked, "How many people do you think died in your city last year?" Their guesses ran all the way from 60 to 300 deaths a year. As a matter of fact, there were 508 deaths, or nearly as many as all their estimates put together. These five representative citizens had no knowledge of the number of deaths that were occurring in their city, and consequently, had no idea how many of these deaths were preventable, or whether the death rate was increasing or decreasing.

But what would be the advantage of knowing all of these facts regarding the death rate and the occurrance of deaths, if it were only to satisfy curiosity, or to furnish scientific data on the subject? Very little, if no other end could be served. And this is the reason why laymen and members of legislatures have, until recent years, taken but little interest in this subject. What is the benefit to the community of knowing how many deaths resulted from malaria, or typhoid fever, in a given area in a given time, if it is not possible to use this knowledge for the prevention of disease, and the reduction of the death rate? In previous generations, when the causes of these diseases were unknown and there was no way of preventing them, mortality reports had only a statistical value. But health is today no longer an accident, and disease and death are to a very large extent, controllable. The advance in scientific knowledge in the last forty years, has placed in the hands of the medical profession, positive means for the prevention of many of the diseases which in past generations inflicted the heaviest loss upon humanity. There is no longer any excuse for any community suffering from typhoid and typhus fever, malaria, yellow fever, bubonic plague, Asiatic cholera, syphilis, gonorrhea, hookworm, diphtheria, and tuberculosis. These diseases are all solved problems from the scientific point of view. The specific cause and the life history of the organism, the means of transmission and the methods of prevention of these diseases are known. Their prevention only requires the practical application of well known and demonstrated facts. The problems presented by these diseases are not scientific at all, but purely sociological. Typhoid fever is no longer regarded as due to a visitation of God, or to a judgment from Heaven. It is due to

dirty water, dirty milk or flies. Malaria and yellow fever are not "pestilences which walk in darkness." They are, on the contrary, due entirely to the presence of a particular variety of mosquito which bites the person suffering from the disease, and then, by biting a well person, conveys the disease to him. Yellow fever and malaria can, therefore, be absolutely prevented, either by destroying the breeding places of the mosquito, or by screening all patients suffering from these diseases. Asiatic cholera is due to polluted food or water. Bubonic plague is transmitted by rats and fleas. Rocky Mountain fever is carried by the tick. Typhus fever, known in past ages as ship fever, jail fever, prison fever, camp fever and famine fever, is now known to be carried by the louse. We are just beginning to realize the cold, practical truth of Louis Pasteur's statement, now nearly half a century old, "It is within the power of man to cause all contagious diseases to disappear from the earth." Public health is no longer a question of accident, it is purely a question of money. A health department with an appropriation of forty cents per capita per year, can save so many lives. A health department with an appropriation of $2.00 per capita per year, can save many more. We can save these lives if we are willing to pay the price. Our cities and states can reduce their death rate if they are willing to spend enough money. The number of deaths which occur in any community is, within certain limits, entirely within the control of the people of that community.

As a result, the death rate, and especially the infantile death rate, becomes an index not only of the sanitary condition, but also of the intelligence and public spirit of the community. It is the record by which the modern public health officer demonstrates his fitness, and shows the results which he has secured. If these facts were only known and appreciated by the public, the annual report of the local health department giving the death rate for the year, would be looked forward to far more eagerly and scrutinized much more s archingly than the tax list or the reports of real estate sales.

Carefully kept records of births and deaths are, therefore, an absolute necessity for modern public health work. For the good of the community, they should be demanded by every citizen, since they offer the only standard by which the condition of public health in the community can be determined, or the effectiveness of the public health organization can be measured.

But while the public health value of vital statistics is probably its most important function, there are other results

almost as valuable, which comes from a careful recording of births and deaths. To the lawyer, to the parent and to the man of property, they are of the utmost importance. It is difficult to understand why the legal profession of the United States has for years permitted such disgraceful conditions regarding birth registration, when one considers that on the proper registration of births depend the solution of questions of identity, parentage, legitimacy, descent, inheritance of property and relationship. In this connection, a number of interesting instances have been reported. Dr. J. N. Hurty the efficient Secretary of the Indiana State Board of Health, tells of a farmer's daughter, whose father, dying, left his property in trust in the hands of his brother, her uncle, to be turned over to the daughter when she became of age. When her eighteenth birthday arrived, she demanded the property, and was informed by her uncle that she was mistaken regarding her age and she could not gain possession of her father's estate for two years more. She had no record of her birth, both her father and mother were dead, and there seemed no way of establishing her age by evidence. Finally a neighboring farmer remembered that a calf had been born upon his farm the same week that the girl was born. He produced his stock record showing the date of the birth of the calf, and made affidavit that the girl was born at the same time, and by the record of the calf's birth the age of the girl was legally established.

Another occurence illustrates the importance of proper birth registration. A young German came to this country some fifty years ago. Landing in New York, he remained there for a couple of years and married. Later on he came west, with his wife and baby. The child grew to manhood, and both father and mother died. Recently a German lawyer came to this country looking for heirs to the estate of the father of the young German, the grandfather of the boy. He had no difficulty whatever in locating the young man, who was naturally overjoyed to learn that he was heir to a considerable estate. But when an effort was made to secure legal evidence of parentage, as well as legal evidence of the marriage of the father and mother, no record could be found. The young man knew by family tradition that the wealthy man who had died in Germany was his paternal grandfather but he was unable to produce any evidence that would be acceptable to the German authorities, and as a result, the entire estate was lost to him.

Registration of deaths is equally important from a legal standpoint. It frequently becomes necessary not only to

prove the actual fact of death but to prove the time and circumstances, the cause of death, the duration of the last illness, the place of interment, etc.

While death registration is progressing faster than birth registration, there are still eleven states in which no authentic record is kept of deaths. Of this number, I regret to say is our own state of Illinois. There is at present upon the statute books of the state, a law providing that all births and deaths shall be registered, but providing no adequate machinery for carrying out these provisions. The result is, that outside of Chicago and a few of the other large cities, there is today in Illinois no record of either births or deaths worth considering. How many people died from tuberculosis last year in Illinois? No body knows. How many people died from typhoid fever? How many babies died under three years during the past year? How many people died of preventable diseases? Is the death rate increasing or decreasing? No one has any idea nor can they know, until a law is pased which will provide for registration of births and deaths in accordance with the methods used in other states.

But the registration of births and deaths has more than a legal and sanitary value. Good health either of the individual or of the community, is today a business asset. That community which has the lowest death rate and the lowest proportion of illness and disability from preventable diseases, is the most desirable for residence, for the investment of capital and for the establishment of manufacturing enterprises. This fact is just beginning to be realized. Consequently, the accurate registration of births and deaths as the only means by which the death rate of a locality can be determined should be of the utmost interest and concern to all business men of a community. An illustration of this occurred a few years ago in a southern state. A land improvement company in one of the largest southern cities was putting forth special efforts to interest northern capitalists and manufacturers, looking for suitable sites. A prominent northern manufacturer was shown a tract of land which exactly suited his purposes, and was prepared to invest a large sum of money in purchasing the land and still more in erecting a large factory. After all the other conditions has been discussed, he stated that the only reason he hesitated, was fear that that particular portion of the state was unhealthful and that it would not be safe for him to take his family and make his home in the southern city. The representative of the land improvement company indignantly insisted that the locality was one of the most healthful in the country, whereupon the northern manufacturer asked for the death rate for that section of the

state for the last five years. The Secretary of the land improvement association at once wrote to the Secretary of State, asking for the desired information. The Secretary of State referred him to the Secretary of the State Board of Health, who replied: "Neither I nor anyone else can tell you how many people died in this state, or in any portion of it, either last year, or the year before, or for any period since its organization as a state. We have no registration of births and deaths. We cannot tell whether our death rate is higher or lower than that of any other state, or whether it is increasing or decreasing. You can find out how many horses and cattle and pigs there are in the state and what diseases they suffer from and how to prevent them, but no one in the state knows anything about the births and deaths of human beings."

This situation came with such a surprising shock to the members of the land improvement association that they immediately began an agitation for a registration law, which, I am glad to say, has since been secured.

Such a law is quite as important to laboring men and women, as it is to capitalists and land owners. Labor unions have, for many years, been endeavoring to secure laws for the prevention of child labor, the desirability of which hardly needs to be discussed. But such a law, in order to be effective, must fix a definite age before which employment will not be permitted. How can such a legal age be established in an individual case? Only by the presentation of a certified copy of the birth certificate. Unless this is done, violations of the law are not only frequent, but their detection and punishment are practically impossible. The child comes to the employer with a false statement from his parents that he is over fourteen or sixteen years of age, whatever the legal limit may be. The employer accepts the statement and employs the child. If the inspector finds the child to be under age, the responsibility for the deception is divided between the parents and the employer. The honest employer never knows when he is breaking the law, while the dishonest employer can not be convicted. If the child were required to present a certified copy of a birth certificate, there would be no question about his real age, and the responsibility could be definitely fixed on the employer who knowingly violated the law, while the law-abiding employer would be protected from deception.

All of you doubtless remember the terrible mine disaster which occurred at the Cherry Mine a few years ago? But how many of you know that it was a child under the age of sixteen, illegally employed on an illegal school certificate issued by the school authorities and sworn to by its parents, who

pushed the bale of hay into the lighted lamp, and that it was another child under the age of sixteen, employed on a notary public's affidavit on the perjured testimony of its parents, who pushed that bale of hay into the mine, causing one of the most frightful disasters in the history of the mining industry of the country. If every birth was registered, the enforcement of the child labor laws and factory laws would be greatly simplified and strengthened.

Women's clubs and social organizations should also demand the passage of such a law for the protection of women and girls. Laws regulating the age of consent are equally valueless without birth registration. In practically all prosecutions for the protection of children and young girls, the contest comes over the age of the girl. If this fact was a matter of official record, the enforcement of the law and the punishment of its violators would be easy.

To sum up the entire situation, in so far as it interests us as citizens of this state, the proper registration of births and deaths is fundamental to any proper and adequate social organization. It is to our discredit as citizens that Illinois is not one of the eight states which register births, nor one of the thirty-six states that register deaths. Outside of Chicago, Peoria and a few of the larger cities, there is no death registration, while even in Chicago the birth registration is incomplete and unsatisfactory, and elsewhere in the state it practically does not exist. The present law is ineffective and inadequate. It has been a dead letter ever since its passage in 1903. For the sake of future generations, as well as for the enforcement of law and order and the securing of better sanitary conditions, it is the duty of each one of us to use all his influence in enlightening the public and demanding from the state legislature, the passage of a modern, up to date, scientific registration law in order that this blot on our state may cease to exist.

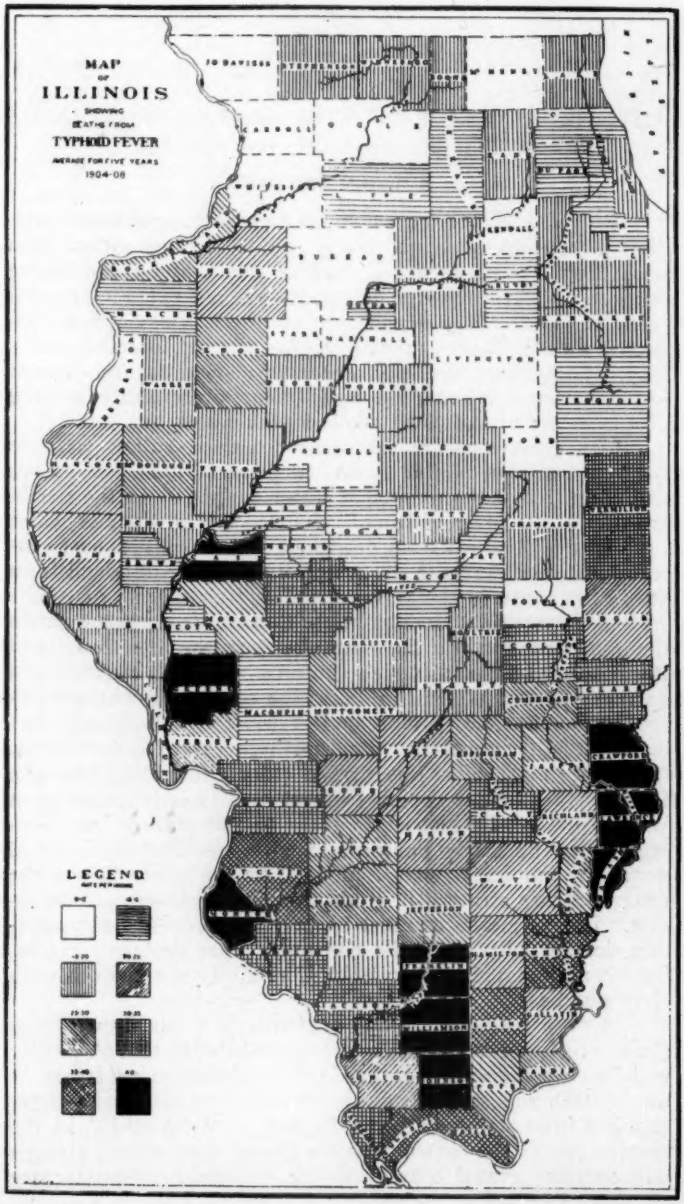
THE EXPERIENCE OF THE STATE OF ILLINOIS WITH THE SHALLOW WELL.

EDWARD BARTOW

Very few Illinois cities obtain their municipal water supplies from shallow wells. Many people in cities either from necessity or preference use shallow well water for drinking purposes. Oftentimes the city mains are not extended to new sections. Oftentimes in old sections the houses are not connected with the mains, making the use of a shallow well necessary. Oftentimes the city water furnished has unpleasant physical characteristics like taste, color, or turbidity causing people to prefer the clean shallow well water.

In a great measure the relative use of shallow wells in different sections of the state is dependent upon the source and character of the municipal water supplies. In the northern part of the State of Illinois, the majority of the city water supplies are obtained from deep rock wells. In the east central portion of the state the water supplies are obtained from deep drift wells, in the west central and southern part of the state from streams. It is possible to have deep rock wells in the northern part of the state because the St. Peter and Potsdam sandstones which outcrop in the central and northern part of Wisconsin dip to the southward so that they are from a few hundred feet to two thousand feet below the surface in the northern third of Illinois, or rather north of a line drawn from Quincy to Chicago. Because the height above sea level in Illinois is less than in Wisconsin, wells which enter these two strata are free flowing or can be easily pumped. Such wells furnish an ideal water for municipal water supply. As the water lies in the water bearing stratum it is absolutely free from contamination. Proper measures must be taken to prevent contamination during delivery to the consumer from defective casing, from contaminated reservoirs, or from faulty connections with river supplies.

In deep rock wells along or south of a line drawn from Quincy to Chicago there is a strong probability that the water will be very highly mineralized. It is therefore necessary in the central and southern parts of the state to obtain water supplies from sources other than deep wells in rock. In the eastern part of the central area the glacial drift is deep enough and contains gravel coarse enough to furnish a satisfactory


MAP
OF
ILLINOIS
SHOWING
DEATHS FROM
TYPHOID FEVER
AVERAGE FOR FIVE YEARS
1904-08
LEGEND

water bearing stratum. We therefore find many of the cities in this area obtaining their water supplies from wells from 100 to 200 feet in depth. These waters are also prefectly free from contamination in the water bearing strata and if properly cared for, furnish a perfectly hygienic supply.

In the western part of this area and to the south of a line drawn from St. Louis to Danville, the drift is not deep enough to furnish sufficient reservoir capacity and it is necessary to rely on surface waters for municipal supplies. Very few of the surface water supplies in this section of the state have been filtered. The unfiltered water supplies are not only unattractive for drinking but they may be contaminated or even infected. With unattractive municipal supplies the citizens in this section use water from shallow wells which may be impure.

Under such conditions we expect a higher typhoid fever death rate in the southern part of the state than in the east central and northern parts.

A study of the statistics collected by the State Board of Health from 1904 to 1911 (*) shows this to be the case. Dividing the state into two parts, (see map) 51 counties to the north and the same number to the south, we find in the northern part of the state but two counties with a rate exceeding 30 per 100,000 and not one county with a typhoid fever death rate of 40 per 100,000. Sixteen of these northern counties had a rate of below 10 per 100,000.

In the southern part of the state there were five counties with a typhoid fever rate of more than 40 per 100,000 and 12 more with a typhoid fever death rate of more than 30, and but one with a rate below 10 per 100,000. It is gratifying to note that the average for the eight years, 1904-11 is better than the average for the five years 1904-8.

Another reason for typhoid fever in the southern part of the state is the fact that 32 per cent of the towns of more than 1,000 inhabitants have no water supply, whereas in the northern part only 10 per cent are without a water supply. Shallow wells are of course used where there are no municipal water supplies and it is certain that the use of shallow well water is influential in spreading typhoid fever.

We have carefully classified all well waters sent to the Survey for examination during the years 1907-12. The waters received have been classified according to depth as follows: Less than 25 feet, 25 to 50 feet, 50 to 100 feet, over 100 feet, and unknown. The variation in the quality of each class from year to year is but slight as indicated on the diagram. The

*Proceedings Illinois Water Supply Association. 2, 151-164.

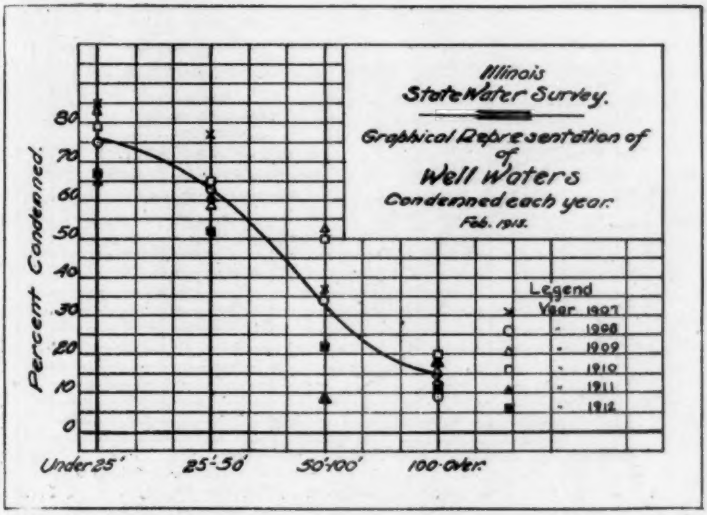
Purity of Well Waters.

Showing Percentage of Well Water Condemned Annually by the Water Survey. Arranged According to Depth of Well.

	1907	1908	1909	1910	1911	1912	Total
Less than Twenty-five ft.—							
No. Examined	284	254	242	148	113	168	1209
No. Condemned	240	192	183	118	74	113	920
Per Cent Condemned	85	75	75	79	65	67	76
Twenty-five to Fifty ft.—							
No. Examined	224	395	354	201	196	353	1723
No. Condemned	173	250	226	137	122	185	1093
Per Cent Condemned	77	63	63	65	62	52	63
Fifty to One Hundred ft.—							
No. Examined	111	192	161	90	89	129	772
No. Condemned	42	66	54	46	8	28	244
Per Cent Condemned	37	34	53	51	9	22	32
Over One Hundred ft.—							
No. Examined	161	312	376	205	171	339	1564
No. Condemned	22	31	62	43	30	49	237
Per Cent Condemned	13	9	16	20	17	14	15
Unknown Depth—							
No. Examined	88	46	72	67	19	27	319
No. Condemned	34	22	38	35	9	6	144
Per Cent Condemned	38	47	52	52	47	22	45
Total No. Examined	868	1199	1205	711	588	1016	5587
Total No. Condemned	511	561	563	379	243	381	2638
Per Cent Condemned	60	46	47	53	41	38	47

average number condemned decreases with the depth of the well. Of those less than 25 feet in depth 76 per cent were condemned, of those 25 to 50 feet, 63 per cent were condemned, of those 50 feet to 100 feet, 32 per cent were condemned, of those 100 feet in depth only 15 per cent were condemned and many of the deepest were condemned because of excess of mineral content and not because of contamination. Of those of unknown origin 45 per cent were condemned. Of all the well waters received during the six years, 47 per cent were condemned. It is gratifying to note a decrease in typhoid fever during the latter part of the period.

Without doubt the above does not give the true idea of the actual condition of the water obtained from wells throughout the state. As a matter of fact a majority of samples sent to the Water Survey for examination is sent because of typhoid fever among those using the water. A truer estimate



of the actual character of the waters of the state can be obtained from a study of waters collected by representatives of the Survey from typical farm wells. The number of samples examined is comparatively small. While 73 per cent of

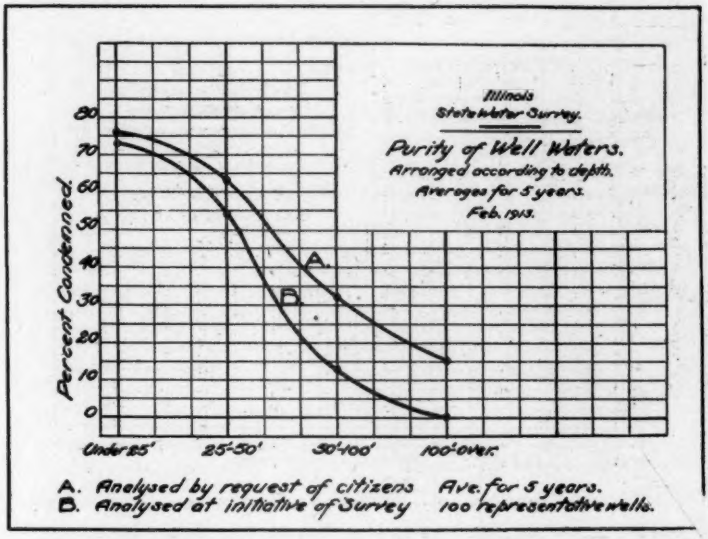
Farm Wells.

Samples Collected by the Survey and Should Represent Average Conditions.

	Less than 25 ft. deep.	25 ft. to 50 ft.	50 ft. to 100 ft.	More than 100 ft.	Total
No. Examined	15	41	15	29	100
No. Condemned	11	22	2	0	35
Per Cent Condemned	73	54	13	0	35

those less than 25 feet deep were condemned, only 54 per cent of those from 25 to 50, 13 per cent of those from 50 to 100 feet, and none of those over 100 feet in depth were condemned. The diagram shows the relation between the character of samples analyzed by request of citizens and of those analyzed on the initiative of the Water Survey. Those collected by the survey are of better quality.

The results of the examination of the water from shallow wells showed three-fourths of them to be contaminated and possibly dangerous. An ideal remedy would be to abolish



all shallow dug wells but the ideal cannot be obtained in this as in many other matters.

As indicated in the discussion of the sources of municipal water supplies in the state, it is impossible in some parts of the state to obtain a satisfactory water from deep wells so that the shallow well is a necessity. Whenever the water bearing stratum is porous enough to allow free flow, a driven or bored well less than 50 feet deep should furnish satisfactory water. In many cases however the flow through the water bearing stratum is so small that it is necessary to make a reservoir into which the water may slowly percolate and from which it can be drawn as needed. Hence the shallow dug well is a necessity. Granting that it is a necessity, great care must be taken to protect the water. The character of the strata which it penetrates must be taken into consideration. Strata of sand may serve as a filter and purify the water. Strata of clay or other material through which water may flow in crevices or cracks may allow pollution to be carried a considerable distance. Wells should be located on a higher level than cesspools, privies or barnyards and these must be built at a distance from the well. The immediate surroundings of the well must be carefully protected. A surface water should not be allowed to pass through the casing within at least four feet from the top. The cover should be tight so that water from the pump may not flow

back into the well carrying with it the dirt and filth from the well cover.

If typhoid fever does break out we wish to emphasize the fact that about the last thing to do is to send water for examination. Typhoid fever infection has taken place from 10 days to two weeks before the symptoms are recognized. There are other sources of typhoid fever and even if the water were the cause, during the time between infection and the outbreak of the disease the water in the well may have lost its infection. Rather should the patient be cared for that he may not again infect the well or infect others by contact. The water may be analyzed but it will require from one week to ten days to obtain the results of an analysis and in the meantime infection may have spread through other means. It is the wisest course to protect the well so that infection cannot enter, making the water safe at all times.

I wish to acknowledge the assistance of Carmen F. Harnack and W. F. Langelier in compiling the statistics and arranging the data for this paper.

THE CONTROL OF STREAM POLLUTION

PAUL HANSEN

In uninhabited or even rural districts the evil results of stream pollution are practically negligible, but in localities where there are urban districts, streams are rendered exceedingly foul by the enormous quantities of sewage and industrial wastes that are poured into them from city sewers. These streams become totally unfit for pleasure purposes, the land along the banks is depreciated in value and public water supplies drawn from the streams may be grossly contaminated and constitute an extreme danger to public health. In the past and even at the present time an enormous toll in human lives is annually exacted as a result of polluted streams not to mention the economic loss due to depreciation in property values. Notable examples in this country of streams which have been rendered foul and useless, other than as open sewers through excessive pollution are the Passaic River in New Yersey, the Naponset River in Massachusetts, and Mill Creek in Ohio near Cincinnati In our own state we have the Chicago River and the Chicago main drainage canal which are becoming so contaminated that it will be necessary to spend millions of dollars for sewage treatment unless the government permits the diversion of increased quantities of water from Lake Michigan.

To prevent the evils of stream pollution gaining too great headway, central governmental control backed by intelligent public opinion is essential. The moulding of an intelligent public opinion is, however, a rather difficult matter for even among persons who have given considerable thought to sanitary subjects, there exist gross misconceptions as to the logical and practicable way to treat the problem of stream pollution. There has been a tendency to permit sentimentality to get the upper hand and this has resulted in giving wide currency to some extravagant demands that are wholly impracticable. There is, however, a group of sanitary engineers who have come into intimate contact with actual problems relating to the prevention of stream pollution and among these engineers there has gradually come about a unanimity of opinion regarding certain essential factors relating to the stream pollution problem. It will be the object of this paper to present these opinions and the statements made will be largely based upon recent careful inquiries among sanitary engineers and others interested in sanitation.

The subject may best be treated by first considering in a broad way what the functions of a stream really are. Having reached a satisfactory conclusion upon this point, it will be possible to consider certain special uses of streams with respect to stream pollution.

General Functions of Streams.

One extreme view of the functions of streams is that they are provided by nature for conveying water to the populations that live upon their banks to be used freely for all purposes for which water may be needed and that, therefore, no one has a right to defile streams by discharging into them impurities which may injure health, reduce the value of the water in the stream for any purpose or add to the discomfort of the water user at points lower down upon the stream. Further, it is argued that common decency damands that a community dispose of its excrementitious matter in some other way than by passing it on to neighbors.

The other extreme view is that streams are our natural drainage courses and that they were provided by nature for carrying off all the wastes of human activity and that to deprive persons of the right to so use streams is an injustice.

In point of fact both of these views contain elements of right, and yet both are wrong. The proper conception of a stream recognizes the dual function of watering and draining the country through which it passes. Some pollution of streams is inevitable; for with increased density of population, increased cultivation of the soil and increased numbers of urban communities it is practically impossible to prevent

the discharge of all deleterious matter into streams. It is only reasonable to require that the pollution of streams be maintained at less than a certain fixed maximum and this permissible maximum pollution must vary according to the character of the stream, the population along the banks of the stream and the uses to which the waters of the stream are placed. The extent of pollution that is reasonably permissible in streams will be discussed somewhat in detail under the headings, "Streams Used for Public Water Supplies," "Streams Used for Recreation Purposes," "Fish and Shell Fish," "Discharge of Manufacturing Wastes into Streams," and "Legal Control Over Stream Pollution."

Streams Used as Sources of Public Water Supplies

Since streams in the ordinary course of events must receive more or less contamination, it follows that public water supplies drawn from surface streams must of necessity be polluted and should not be delivered to the consumers unless the water is first adequately purified. One exception may be made to this general rule, namely, in the case of water supplies derived from streams draining comparatively small water sheds. In such cases it is sometimes feasible for the water-supply authorities to own the entire watershed and control it in such manner as to make cantamination of the water courses impossible. But in general we have this question to contend with—how much pollution may be permitted to enter a stream before the water thereof is polluted to a point beyond redemption by water purification methods? This is a question that taxes the greatest ingenuity of sanitary experts and it is always necessary for any specific problem to be considered on its particular merits in order to obtain what is the best and most economical solution.

Merely to indicate the wide range of conditions that are met in actual practice, we have on the one hand a water purification plant constructed for the purpose of purifying crude though rather weak sewage at the Chicago stock yards. It was claimed that the results obtained at this plant were satisfactory when judged by analytical standards and by the safety of the water for human consumption. Even though it is possible to transform such a filthy liquid into drinking water, the esthetic sense of the community rebels and it is not probable that water once so highly polluted, even with most thorough purification, will ever be considered as acceptable water for public water supplies. At the other extreme is the community which derives its supply from a clear mountain stream, possibly having its source in large springs yielding a water of unquestioned purity. In such a case there would seem to be but trifling danger, and authorities might be tempt-

ed to omit purification of such a water. The disastrous results that may come from this ommission is well illustrated by the experience in Plymouth, Pa., in 1885. In this case the source of water supply was a mountain stream such as above described, with but two houses upon the entire drainage basin. Nevertheless a single case of typhoid in one of these houses was responsible for 1104 cases and 114 deaths among the consumers of the water.

Notwithstanding the great difficulty in defining that degree of pollution which is permissible in streams which are to be used as public water supplies after purification there would seem to be an advantage in attempting to approximate a general rule for the control of such streams. A rule has been formulated in the light of the present available evidence, but it must be admitted that this rule is not based upon any very scientific data and it can, therefore, only be put forward tentatively with the expectation that it will be modified from time to time as more and more experience is acquired. This rule may be stated as follows: The time in hours required for the passage of a particle of water from the sewer outlet to the point of water works intake during high water, multiplied by the dilution available during low water in cubic feet per second per 1000 persons tributary to the sewers, should equal a constant and this constant should not equal less than 40. This may be expressed mathematically as follows:

T x D equals C.

In which T equals time in hours required for the passage of a particle of water from the sewer outlet to the water works intake at high water;

D equals dilution available during low water in cubic feet per second per 1,000 persons tributary to the sewers; and

C equals constant, which it is recommended be not less than 40.

The above formula applies to streams in which there is no appreciable increase in volume of flow between sewer outlet and the point of water works intake. In the case of streams which receive the discharge of large tributaries between the point of sewer outlet and the point of water works intake, the formula must, of course, be modified. Generally it will be merely necessary to assign a value D which represents the mean of the quantity of water flowing past the sewer outlet and that flowing past the water works intake. If the factor of safety proves to be more than 40, purification of the sewage will not be necessary for the protection of the water supply. If the factor of safety is less than 40, some

form of purification will be necessary and this may vary all the way from plain sedimentation to intermittent sand filtration followed by sterilization.

The formula, of course, is intended to be used as a rough guide and it is conceivable that there are instances where it will not apply. Take, for example, the case of a very large stream, where a sufficiently large factor of safety may be obtained with the sewer outlet at a very short distance above the point of water works intake, and on the same side of the stream; here it is manifest, due to the impracticability of securing a mixture of the sewage with the entire volume of the stream that the sewage must receive treatement or the water works intake must be extended to a point above or at any rate beyond the influence of the sewer outlet. As a rough guide, however, such a formula may serve a useful purpose in narrowing down the widely divergent practice of the present time.

Streams for Recreation Purposes

Of recent years growing importance, is attached to the maintenance of our streams for pleasure purposes. Every summer there may be found scattered along the streams within a radius of 50 miles or more of our large cities numerous camps. This form of sûmmer vacation is a comparatively cheap and normally a healthful means of recreation. It ought to be regarded as one of the means of improving the health tone of our urban communities inasmuch as it is within the means of so great a number of people.

Under this head may be asked how high a degree of purity should be demanded in a stream which is extensively used for recreation purposes, but not for public water supply? Within the last few years much emphasis has properly been placed upon the purification of sewage by dilution, which after all, is purification by oxygenation in which a natural resource is utilized instead of an artifically constructed purification works. It has generally been held and in most instances rightly held that the degree of dilution necessary is merely that which will prevent a nuisance, having reference primarily to unsightly floating matter and bad odors. For most rivers and many of the smaller streams of the country, this requirement as to the cleanness of the waters is all that is necessary.

There is, however, a certain class of streams which because of the beauty of the country through which they flow and their specially favorable location becomes highly prized for camping and recreation purposes. It is a striking circumstance, in fact, that recreation seekers nearly always look for

the stream valleys which illustrates the craving of man for a combination of land and water, by means of which nature presents her most alluring and most picturesque aspects. These streams, as a rule, have no large cities upon their banks but merely here and there a small town or village. The sewage from such small towns and villages may not be sufficient to produce a visible coontamination except possibly throughout a very short distance below the sewer outfalls, but such contamination does offend the esthetic sense and undoubtedly does add some danger to public health for the reason that when a stream is used for recreation purposes, it will be used for boating and bathing and as a domestic supply to some extent among campers, though it may not and should not be used for drinking water. It seems to the writer that such streams as those deserve greater protection against contamination than merely to prevent nuisance.

No definite rules to apply to all cases can be laid down, but as a general principle, it may be said that if such a stream is not polluted to any material extent by storm water and street wash such as would obtain in the case of a city of considerable size located upon the banks, it would seen perfectly feasible to purify the sewage to a point where it will give no evidence of its existence even in the vicinity of the outlet and further the sewage effluent should be sterilized by the cheap and satisfactory means of using bleaching powder so as in large measure to guard against dangers to health among vacationists which may result from boating, bathing and domestic uses of the stream water, other than for drinking.

A very striking example of a stream serving the useful function of providing recreation for vacationists is the Little Miami River near Cincinnati. The lower reaches of this stream are lined with cottages and tents of campers during the summer months and it requires but a very little contamination of the stream to immediately give rise to a storm of complaint. There are few villages located on this stream and these contribute some minor manufacturing wastes and a negligible quantity of street wash. If the sewage from these towns were purified, and it is understood that purification works have been ordered by the Ohio State Board of Health, the stream could be preserved for what appears to the writer to be its highest and most valuable use, namely, recreation.

Fish and Shell Fish

Many streams are valuable to the community on account of their fish life. It may be said in general that there is rarely necessity for so polluting a stream as to endanger fish life, though there are some circumstances where the continu-

ance of certain liquid waste producing industries injurious to fish is of so great importance to the general welfare that fish life in certain streams must be sacrificed.

The maintenance of fish life does not necessarily imply an unpolluted stream. It is merely necessary that the alkalinity of the water be maintained and that the pollution be not so great as to absorb the dissolved oxygen in the water to an extent that will suffocate the fish. The fact is: a moderate degree of pollution favors fish life in that it favors the growth of microscopic aquatic organisms which constitute valuable fish food. Certain difficulties have been encountered in the contamination of fish by polluted water which causes the fish to decay rapidly and become unfit for human consumption. The danger of infection of human beings with specific disease through eating fish taken from polluted streams is almost negligible, for the reason that in this part of the world at any rate fish are not eaten raw. With shell fish, however, the case is quite different, because they are very frequently eaten raw. It has been a common practice along the coast to float oysters in shallow polluted waters which causes them to become bloated and appear fat. Such an oyster perhaps makes a more delectable morsel of food, but in it may be lurking the germs of typhoid fever or some other water borne disease. The problem of protecting the shell fish industry is a very complicated one and all its intricacies have not been worked out. Here again is where the services of experts are needed to study each zone of shell fish pollution in the light of diverse local conditions. As a concrete example of the efforts that are made to protect shell fish may be mentioned the case of the city of Baltimore, which at the expense of millions of dollars is purifying its sewage so as to convert it into a liquid which is not only clear and inoffensive but also practically sterile.

Discharge of Manufacturing Wastes into Streams

Many of our important industries, such as paper mills, woolen mills, dye works, starch factories, and tanneries, require large volumes of water to carry on their industrial operations and they also produce large volumes of waste which are capable of undergoing offensive putrefaction. The discharge of these wastes into streams often causes unsightly, and malodorous conditions, yet, with the exception of tanneries, these waters do not menace the public health since they do not contain the specific infections of disease. (Tannery wastes may contain anthrax bacilli). In fact some of the processes are such that the wastes are quite inimicable to the existence of disease germs. In some cases it is practicable

to treat the wastes so that offensive conditions in a stream may be in part or wholly relieved, but for certain industries such treatment of the wastes is prohibitively expensive.

Enjoining industries against causing objectionable stream pollution may, and in some instances actually has, necessitated the shutting down of works. It is conceivable, in the case of large industires upon which are dependent a considerable population, that an order to cease stream pollution, which is virtually an order to shut down the works, might result in great hardship without adequate returns accruing from the cleaner conditions of the stream. There may be instances, therefore, where a limited few of the streams of the country may legitimately be turned over to the manufacturing interests. Now that the stream pollution problem has become more acutely an issue and the disadvantages of filthy streams is better understood it would not seem wise to permit waste producing industries to be located upon any but very large streams which have an ample volume to dilute the wastes to an inoffensive condition. That is to say, the streams which are now clean should be maintained clean for the reason that we have an ample number of large streams which can effectually take care of wastes from waste producing industrial plants for an indefinite period in the future.

Legal Control Over Stream Pollution

A discussion of stream pollution would not be complete unless some consideration is given to legal control. As already indicated the cleanness of streams cannot be conserved unless under a central governmental supervision. If left to individual communities, very little could be expected in the way of results. Communities are not likely to be altruistic enough to spend large sums of money for sewage purification works to protect neighbors on the stream below unless such altruism is induced by damage suits which render sewage purification the cheapest way out of the difficulty. But law suits are costly if long drawn out and the results are often unsatisfactory.

It is essential that specific problems relating to stream pollution must for successful solution be placed in the hands of experts and it is, therefore, necessary or at least strongly advisable that every state have an expert commission. Among many there is a strong prejudice against commissions inasmuch as the multiplication of commissions is looked upon as a delegation of legislative and executive powers to others than direct representatives of the people. This need not necessarily be so, however, for a law may be framed requiring in general terms that streams must be maintained in an inoffen-

sive condition and that they shall not be detrimental to health. This leaves to the commission not arbitrary powers, but the simple function of determining points of fact within limits prescribed by prior legislative enactment. That is to say, the commission will determine when a stream is in danger of being made offensive and when it is in danger of being made detrimental to health, and thereupon decide what, if any, purification of sewage is necessary, what, if any, purification of industrial wastes is necessary, whether water supplies may or may not be taken from streams and to what extent they must be purified. Such a commission should be supplied with ample appropriations to enable it to obtain all necessary information for its guidance whether this consists in maintaining laboratories or carrying on experimental and research work. As even the best of commissions may at times grow arbitrary or become unduly baised in its views there should alawys be made provision for ready appeal from the decisions of a commission to an independent special arbitration board of experts, and, of course, there must exist the inalienable right of appeal to the courts.

Summary

Summarizing in the briefest possible terms, it may be said that all surface streams must of necessity be polluted to an extent that renders them unsafe as domestic water supplies without purification. On the other hand the public is entitled to clean streams and special protection should be afforded to those streams which because of their beauty and accessibility from the cities constitute valuable recreation grounds for urban populations. When not a menace to health, certain exceptions may be permitted with respect to the maintenance of clean streams. Such exceptions, however, must always be regarded as special cases, necessitated by unusual local conditions. A limitation of stream pollution is most effectively and most equitably carried out when under the general supervision of some central expert authority operating under somewhat elastic general laws which represent in broad terms the will of the people.

SANITARY ASPECT OF MILK SUPPLIES.

P. G. HEINEMANN.

Sanitary milk is a much debated question in modern times. Milk is one of the most important articles of food and, including milk products—such as butter, cheese, buttermilk, etc.,—forms the basis for dishes or beverages at every meal. During the first year of human life milk is practically the only food. Milk is also excellent food for bacteria, which multiply in milk at an enormous rate. The production of milk is one of the oldest industries known. Methods of production have been brought down through many generations and consequently are difficult to change. The tendency of the milk traffic of today is towards concentration. Still there are probably more producers of milk in relation to the total amount of milk consumed, than of any other commodity.

Improvement in milk supplies must come from various sources and the problem must be attacked from various angles. Education of producer and consumer is the keynote to the situation. The methods in vogue at present for improving milk supplies are concentrated necessarily on elimination of disease germs. The presence of these germs in milk or water and other articles of food is difficult to detect. Disease bacteria, if present, multiply but slowly in milk, if it is kept at low temperatures. Also, the number of disease germs is usually small if compared with the number of harmless bacteria always present in milk. With modern bacteriological methods, therefore, disease germs are easily overlooked. Indicators have to be used in milk as well as in water. In water the presence of colon bacilli is usually taken as an indication of the presence of disease germs. Colon bacilli come from the intestinal canal of man and may indicate the presence of germs of intestinal diseases. Colon bacilli from other sources are of no value in this respect. Colon bacilli in milk indicate fecal contamination, but since they are derived from the cow, they do not lead us to assume that disease germs are present, since cows are not susceptible to intestinal infections of man. Fecal contamination, direct or indirect through dust, is the most common source of bacteria in milk. It is clear from the foregoing argument, that total numbers of bacteria in milk are, as far as present knowledge goes, the only index by which we can judge milk.

The question now is obvious, whether a low bacterial count is sufficient to guarantee safety of milk. We do not think so. A low count gives no adequate assurance that pathogenic germs from "germ carriers" have not entered. Carriers

of tubercle bacilli, of typhoid bacilli, of diphtheria bacilli, of the germs of scarlet fever may be employed in a dairy and unconsciously communicate the virus of these and other diseases to the milk. The only reasonable safeguard against carriers is efficient medical supervision of dairy employes. Such supervision is of greater bearing than exceedingly small numbers of bacteria.

For pasteurized milk the bacterial count is of importance. Fortunately for us, most pathogenic bacteria are destroyed by efficient pasteurization. In fact, we may safely say, that all pathogenic bacteria which carry infection through the intestinal tract, are destroyed by efficient pasteurization. Bacterial efficiency of pasteurizing apparatus is therefore of similar value as bacterial efficiency of water purification plants.

Reduction of numbers of bacteria and proper medical supervision of employes are the two most important factors in improving milk supplies. Medical supervision is of prime importance when the raw product is to be consumed, but of secondary importance if milk is to be pasteurized. It should be one of the duties of health departments to control pasteurizing machines. The style of machine should be approved by the commissioner of health and the temperature should be recorded automatically. The records may be kept in locked cases, the keys to which are held by the department of health.

The producing dairies should be regularly inspected. The inspectors report on equipment and methods. Only well trained men should be employed as inspectors. They should be familiar with the objects of their work and should approach the producer as friends and advisers, not as officers, who are bound to find fault. Unfortunately inspectors have frequently antagonized producers. Municipal governments are not devoting sufficient funds to employ high grade men as inspectors. The consequence is, that producers object to making improvements and the detrimental influence of such conditions cannot be overestimated. In several states of the Union laws have been enacted, forbidding the enforcement of ordinances, demanding tuberculin testing of cattle. Legislation of this nature is the direct result of antagonism developed among producers. Thus tubercular cattle are permitted to furnish milk which becomes a serious menace to public health.

The distribution of milk should be in bottles only, except for wholesale trade. In large cities the can and dipper have been practically abolished. Proper licensing regulations and periodical inspection of central stations and delivery wagons will control this part of the milk traffic.

Finally we have to consider the handling of milk in the home. This is really the most difficult part of the problem.

Educational pamphlets, bulletins from boards of health, co-operation of the daily press and similiar means of reaching the consumer must be employed. If we can convince the consumer that clean milk is healthful, and should contain but a small number of bacteria, that it should be sold in bottles only, that it should be cold when delivered, that efficiently pasteurized milk is the safest milk under present conditions—if the consumer is convinced of these points, he will demand the right kind of milk and milk of lower standard will be driven from the market.

HOUSING IN RELATION TO HEALTH

MARION TALBOT

There is much confusion in the use of the term "housing." It is often taken to mean, not merely the structure of the house itself, but its equipment, plumbing, furnishing and the like, and its immediate surroundings, such as streets and alleys. It may also include the way in which the house is used or maintained on its physical side, which is more properly housekeeping, or even the way in which the lives of those who occupy the house are ordered, such as overcrowding, which is more properly homemaking. Moreover, much of what is said and written in regard to unhealthful housing is concerned more with the aesthetic standards of decency and order than with health. A scrutiny of many of the pictures which are supposed to represent bad housing shows that these distinctions are frequently not closely drawn. For example, a room may be light, large, well ventilated and yet be a menace to health, because of the unduly large number of people who occupy it or their uncleanly habits. On the contrary, it is possible for a small room with a meagre supply of light and air to be kept so neat and clean as to be quite fit for habitation. Again, many kinds of construction, like back stairways or broken fences, may be ugly but not unhealthful. Higher standards of order or of beauty should be developed to meet this difficulty. A street or alley may be unpaved or even disfigured with rubbish. The aid of the street department, not of the board of health, is needed here. A room may show a disordered bed, a cluttered table, or clothes hanging on a line. Better instruction in homes and schools as to what is good housekeeping should be the remedy sought.

So it is impossible to discuss or criticize housing without a clear understanding of the many problems involved. Many well intentioned efforts to secure proper conditions for living fail because of this confusion in terms.

Taking now the more limited view of housing, i. e., the house and its mechanical equipment, we find that there is much difference of opinion as to the steps to be taken to secure healthful housing. The reason is that sanitary science is undergoing radical and most interesting changes, owing to the development of the sciences on which it largely depends, viz., bacteriology and physiology. Many opinions and practices based on outgrown theories are still deeply rooted and find expression in views concerning housing.

In the interest of efficiency and progress, it behooves those who work for the well-being of social groups to take measures to correct popular misapprehensions and urge the development of engineering and building methods which shall conform to our new knowledge. We need, moreover, not to-cumber further our statutes and ordinances with measures which are not only incapable of enforcement but futile and costly if put in practice. In illustration, some of these new views may be enumerated and some conclusions drawn from them, although within the limits of this paper hardly more than a sketch is possible.

In the first place

(a) The quantity of carbon dioxide is not a measure of unhealthfulness of air.

(b) Ordinary variations in the normal gaseous constituents of air produce no apparent ill effects on people.

(c) The discomfort ordinarily attributed to so-called "bad-air" is due to high humidity combined with high temperature and these conditions derange the health.

Long after the toxicity of carbon dioxide had been disproved, its presence in air was taken as a measure of the defilement of air in other ways, but it is manifestly absurd to assume any constant relation between carbon dioxide and carbon monoxide, which is the only really harmful gas which is likely to be found in houses, or between carbon dioxide and pathogenic organisms, which may be in the air of houses occupied by diseased persons. It is clear, therefore, that any attempt to keep the carbon dioxide down to a fixed limit by renewal of the air supply or in any other way may be ineffective in securing healthful conditions. Consequently, laws requiring the supply of a given amount of air per person or a given cubic space per person fall wide of the mark. The real aim should be toward securing movement of air, since thereby the warm moist blanket of air which gradually accumulates about the bodies of people in inhabited rooms may be removed. In other words, it has been adequately proved that people do not need a large supply of air providing what they have is kept

in a state of motion. This fact probably explains the value of living and sleeping out of doors. Moving air, not stagnant air, is what we need. An increased amount of oxygen does not in itself bring relief. The ill effects of over-heated air of low humidity may be noted in passing, although they present a different problem.

It has recently been suggested that the high rate of mortality among infants in city slums is not chiefly due to the poor quality of their food, but may be in part explained by the fact that they are often so housed that there is no relief from the effects of combined high temperature and moisture. A German scientist points out (Gemund, Wohnungshygiene and Hochsommerklima, Zeitschrift fur Socialwissenschaft, Vol. III, Nos. 7, 8 and 9,) that in small cottage houses on paved, treeless streets there is often no escape from excessive heat. If the people remain indoors seeking shelter, the increased humidity due to evaporation from their bodies adds to the difficulty. Large buildings, planned so that there may be movement of air within and with shaded porches and yards or small parks near by in which there are trees and grass, is a method of caring for as many people in a given area as by the cottage plan, so highly praised from the point of view of so-called ventilation. It is impossible at this time to elaborate this point. I can merely suggest that the findings of the sanitarian should be taken by the architect, engineer, and social student and an effort made to work out methods by which an automatic movement of air may be secured in dwellings without sacrificing other important interests.

In the second place, we know that

(a) Air from properly constructed sewers is not harmful.

(b) Simple plumbing fixtures are an aid rather than a menace to health.

These facts mean that we should greatly simplify our plumbing laws and do everything possible to have plumbing fixtures installed at so little cost that they will be within the reach of everybody. They should be as essential a part of every house as its walls and doors.

Modern sanitation is placing more and more emphasis on personal cleanliness. When those who are used to an ample supply of water, both hot and cold, realize the difficulty of maintaining high standards of cleanliness, it is not hard to understand what results when three or four families and their lodgers have to share one fixture. We often hear that poor people will not use plumbing fixtures, if they have them. The popular illustration is the bath tub in the model tenement

which is used as a coal bin. Few of us would indulge in much bathing, if the bath meant starting a fire and going through the tedious and costly operation of heating a water supply. Better and cheaper methods of distributing both hot and cold water are a genuine necessity in healthful housing.

In the third place, sunlight cannot be depended on for disinfection or as a substitute for cleanliness. Much emphasis has been placed on the importance of securing sunlight in rooms and it has been vigorously urged by those who are combatting tuberculosis. There is danger of placing false reliance upon it. The true value of an abundant supply of light is that it is an aid in revealing uncleanly conditions and serves moral and physical rather than bactericidal ends. Many cities in their ordinances take the position that, if the window space stands in a sufficiently high relation to the floor area, all will be well. This does not necessarily follow, as the window may be so curtained within or so obstructed by nearby walls without as to fail to furnish needed illumination. The natural lighting of every room should be determined by other tests than size of window, such as ability to read ordinary type at a given distance from the window during certain hours of the day. It is of interest as bearing on the construction of houses from the aspect of lighting to note that a recent investigation made in Philadelphia (F. A. Craig, Deaths from Tuberculosis, American Journal of Public Health, Vol. III, No. 1) indicates that there is no relation between the width of the street and the number of deaths from tuberculosis.

In expressing my appreciation of the honor of addressing the members of the Academy, I beg the privilege of asking them to remember that, in so brief a treatment of so large a topic as was assigned to me, it is difficult to keep a due sense of proportion and to present views in such a way that they will escape misconstruction. I trust, however, that I have made perfectly clear my main thesis, which is that, if housing is to bear the relation it should to the maintenance of a high degree of health, it would be well to do away with some of the extravagant and sentimental views which obstruct the way and to develop the effective use of our present knowledge and resources through more active cooperation between sanitarians, architects, engineers, social workers, law makers, house keepers and even owners than now exists.

PAPERS BY MEMBERS

A CELESTIAL SPHERE IN A NATURAL HISTORY MUSEUM.

WALLACE W. ATWOOD

The Chicago Academy of Sciences has appreciated the increasing interest in astronomy and the difficulty which every one meets in trying to become familiar with even the brighter stars, and more commonly known constellations. Various plans for promoting this study were considered by the Academy. The flat star charts are confusing to the untrained observer, and the globes, on the outside of which stars are sometimes represented, are unsatisfactory.

Through the use of the Celestial Sphere, now in the Academy Museum, it is possible to become familiar with all the constellations that are ever visible in the latitude of Chicago. Few people have had the opportunity of seeing all of these constellations for on a given evening it is possible to see but a few of them and the apparent motion is so slow that it would take hours and hours of careful watching to see all of those visible on a single perfectly clear night.

The stars of the first, second, third, fourth and a selected number of those of the fifth magnitude visible from the altitude of Chicago are represented in the Sphere, and the total number is 692. In addition to the fixed stars, four planets, Venus, Mars, Jupiter and Saturn are represented as well as the Sun and Moon. The celestial equator is clearly marked in the interior of the sphere, and the ecliptic, or apparent yearly path of the Sun among the stars, is also shown.

Many of the mathematical conceptions necessary for the study of descriptive astronomy and which often discourage the beginner, are made with this sphere, perfectly simple. There is now no reason why any one, including the younger school children, can not become familiar with the chief constellations their apparent movement, the brighter stars and the real and apparent movements of the Sun, Moon and planets.

Many of the fundamental ideas in mathematical geog-

raphy necessary in elementary education are also easily demonstrated with the sphere.

The sphere now in the Academy building was invented by Wallace W. Atwood, Secretary of the Society and Director of the Museum. It was constructed, installed and presented to the Academy by Mr. La Verne W. Noyes, President of the Board of Trustees, in order to broaden and to promote the educational and scientific work of the Academy.

The Construction

The material used in constructing the sphere is very light galvanized sheet-iron, 1-64 of an inch thick, which has been pressed to the proper curvature and soldered to the equatorial ring and to a much smaller ring about the entrance to the sphere. The separate sheets lap sufficiently to be soldered upon one another. The platform and horizon table are of wood and rest upon a very strong steel frame.

The diameter of the sphere is fifteen feet. The weight, exclusive of the platform, is a little more than 500 pounds. This weight is carried by a tube 2½ inch tube attached to the outside of the sphere along the line of the equator and resting upon three wheels as shown in the cross section view. The two lower wheels carry the greater portion of the weight but the third and upper wheel, above the door, resists a certain thrust due to the inclined position of the sphere. The stationary platform within the sphere is supported in part by steel trusses resting upon the frame work of the museum balcony, and in part by two upright pillars which rest upon the great I beam of the mainfloor of the Museum. This platform carries a circular horizon table, below which the sphere is obscured from view, and above which there is a complete hemisphere on which the stars are represented.

The observer in this sphere is located on the surface of the Earth at North Latitude 41 degrees 50 minutes. Celestial spheres constructed for localities having other latitudes north or south would be placed at other angles and certain other constellations would be represented. Thus a celestial sphere constructed for Buenos Aires, to represent the southern heavens, would be so placed that the observer would enter from the north polar region and see the southern constellations, not visible at Chicago, observe the courses of Sun and Moon north of him but fail to see any of the constellations about the north pole of the heavens as seen from the latitude of Chicago.

Attached to the steel structure supporting the sphere is a small electric motor, which propels the two lower wheels supporting the sphere and their rotation causes the sphere to rotate.

The electric power for rotating the sphere and the light for illuminating the interior are controlled from within the sphere. The electric current necessary for representing the Sun is received at the north pole at a rotary contact, and carried by an insulated wire to the ecliptic, about which there is a wire on the inside of the sphere.

The Fixed Stars

The stars are represented by tiny perforations in the sphere. Different sized perforations have been made to represent stars of different magnitudes. The size and location of each star in the sphere has been determined with great care by using an instrument especially constructed for this purpose, so that the sphere is an accurate miniature representation of the heavens.

The Planets

The shifting positions of the planets Jupiter, Saturn, Mars and Venus among the constellations have been provided for by a number of openings made to represent the different positions of each of these planets at different times of the year. The openings not in use are very readily covered.

The Sun and Moon

The Sun is represented by a small electric light which may be moved from place to place along the ecliptic and thus be kept in its appropriate place among the stars. The Moon will be represented by a series of small discs cut to represent discs may be moved from point to point along the orbit of the Moon and thus represent that body in its appropriate position in the heavens.

Each star in the sphere has been numbered and a series of star tables have been prepared so that it is perfectly simple for one to identify a particular satr observed in the sphere or to locate a given star or constellation .

This appartus should prove to be of great practical value in educational work. The public and private school children should make frequent visits to the sphere and the students in Astronomy in the neighboring Universities will find it well worth their time to arrange excursions with their instructors to the Academy to make use of this apparatus in their studies.

ANNOTATED LIST OF THE ALGAE OF EASTERN ILLINOIS.

EDGAR NELSON TRANSEAU

The following list of algae contains the names of the species that have been observed and identified during a study of algae periodicity extending from January, 1908, to January, 1913. No effort has been made to name all the forms found or to collect new species. All our attention has been directed toward collecting the forms of interest in connection with periodicity at frequent intervals. At this time a large number of the 1912 collections have not been critically studied, although almost all of them have been examined for special purposes. A preliminary account of the classification of our algae on the basis of their periodicity may be found in the "Transactions of the American Microscopial Society" Vol. 32, No. 1, Jan., 1913. As indicated in the text many of these species were originally determined by Mr. F. S. Collins, without whose help this study would have been impossible. Several species are listed under the names I have given them in my notes. These forms will be described elsewhere. Where no locality is mentioned, the stations in the immediate vicinity of Charleston are to be understood. In the collecting of specimens the writer has been greatly aided by Mr. T. L. Hankinson, Mr. Homer Sampson, Mr. E. L. McCabe, Mr. Harry Givens and Mr. Hanford Tiffany. By their generous cooperation it has been possible to make simultaneous collections at widely separated points in eastern Illinois. In addition a number of students have contributed collections of no little interest. To all of these the writer makes grateful acknowledgement. To anyone wishing to undertake the study of the algae of his locality I would suggest the following as the most useful general works. All of them possess bibliographies of the publications dealing with special groups.

1. F. S. Collins, The Green Algae of North America. Tufts College Studies. Vol. 2, No. 3, pp. 80-463. 1909.
2. F. S. Collins, The Green Algae of North America (supplement). Tufts College Studies. Vol. 3, No. 2, pp. 70-109. 1912.
3 G. S. West, A Treatise on the British Fresh Water Algae. Cambridge, 1904.
4. K. E. Hirn, Monographie und Iconographie der Oedogoniaceen. Helsingfors, 1900.
5. J. Tilden, Minnesota Algae. (Schizophyceae) Minnesota Botanical Survey, Minneapolis, 1909.
6. E. Lemmermann, Kryptogamenflora der Mark Branden-

burg. Vol. 3, Algen. (Schizophyceen, Flagellaten, Peridineen) Leipsig, 1910.
7. F. Oltmanns, Morphologie and Biologie der Algen. Two Vols. Jena, 1904.
8. A. Pasher, Die Suesswasserflora Deutschlands, Oesterreichs und der Schweiz, Jena, 1912.

Schizophyceae

Chroococcaceae

Chroococcus turgidus (Kuetzing) Naegeli.
Ponds. Seen in many collections but always in small numbers.

Aphanocapsa brunnea (A. Braun) Naegeli.
Abundant in the East Tile Factory pond, Charleston, July, 1909.

Aphanothece stagnina (Spreng) A. Braun.
Common in summer and autumn in the Tile Factory ponds, and the east Big Four pond, Charleston.

Clathrocystis aeruginosa Henfrey.
Very abundant in a small pond adjoining the reservoir, Casey, September, 1912.

Coelosphaerium Kuetzingianum Naegeli.
At times an important constitutent of the plankton in the Tile Factory and east Big Four ponds, Charleston.

Merismopaedium convolutum Brebisson
Abundant in the summer plankton of the Tile Factory and Hodgen's ponds.

Merismopaedium tennuissimum Lemmermann.
Common in the new Tile Factory pond, Charleston, September, 1911.

Oscillatoriaceae

Oscillatoria Agardhii Gomont.
Found in pond near the Casey reservior, September, 1912. Fide Collins.

Oscillatoria amphibia Agardh.
In ponds and streams, occasionally abundant. In the Ice Plant pond, Casey, it was found in the hot water near the steam exhaust. It has been recorded from the east Big Four pond, and the Town Branch near Charleston. Fide Collins.

Oscillatoria formosa Bory.
Found in ponds near Charleston and Casey. Fide Collins.

Oscillatoria limosa Agardh.
Very abundant during low water stages in streams, stream pools, and ponds. Common in streams polluted by sewage. Found at all seasons of the year locally abundant.

Oscillatoria princeps Vaucher.
Very abundant at irregular intervals in ponds and streams. Fide Collins.

Oscillatoria splendida Grev.
Pool in stone quarry northwest of Embarras, March, 1911.

Arthrospira Gomontiana Setchell.
Very abundant during winter and early spring in the middle Tile Factory, and second Big Four ponds.

Spirulina major Kuetzing.
Rare. Has been observed in collections from the Tile Factory ponds and a drainage ditch north of Martinsville.

Phormidium ambiguum Gomont.
Found on shell of a live snapping turtle in stream south of Ashmore.

Phormidium foveolatum
On submerged water plants, Campus lily pond, Charleston.

Phormidium inundatum Kuetzing.
Found in abundance at the north end of the pond on the Brookhart farm, about one mile southwest of Oilfield, April, 1911.

Phormidium uncinatum (Ag.) Gomont.
Common in wet-weather streams and pools in winter and spring. Fide Collins.

Lyngbya aerugineo-coerulea (Kuetz) Gomont.
Abundant in drainage ditch northwest of Martinsville, October, 1910. Associated with Spirulina major. Fide Collins.

Lyngbya aestuarii Liebm.
Abundant in all ponds in the vicinity of Charleston. During a wet period in November, 1909, it grew abundantly and developed a mat on the west bank of Hodgen's pond in association with Rhizoclonium fontanum Kuetzing. Fide Collins.

Nostocaceae

Nostoc carneum Agardh.
Abundant in pool at limestone quarry northwest of Embarras, November, 1910. Fide Collins.

Nostoc muscorum Agardh.
Very abundant during the summer of 1910 in the pools along the Clover Leaf R. R., north of Charleston. Fide Collins.

Nodularia sphaerocarpa Bornet and Flahault.
Found in floating masses on Marshall pond, four miles north of Charleston. Fruits during May. Fide Collins.

Nodularia spumigena Mertens.
Collected in roadside pools near Decker, Indiana, May, 1911 in fruit. Fide Collins.

Anabaena catenula (Kuetz.) Bor. & Fl.
Occasionally common in ponds near Charleston and Casey. Produced spores in Marshall pond, May, 1912.

Anabaena flos aquae (Lyngb.) Breb.
Found but once, in the pond just west of the Greenup station south of the Vandalia R. R. It formed a bluish green scum on the water.

Anabaena inaequalis Bor. & Fl.
During May and June it has been recorded for Hodgen's pond and Marshall pond. Produces spores in May. Fide Collins.

Anabaena laxa (Rab.) A Braun.
Found in material collected in Hodgen's pond during September, 1908. Fide Collins.

Cylindrospermum muscicola Kuetzing.
Recorded from Marshall pond, Charleston, and an artificial pond near Sullivan. Fruits during May. Fide Collins.

Scytonemataceae

Tolypothrix tenuis Kuetzing.
Common on submerged objects in the Big Four ponds, Charleston, and the Ice pond, Ashmore. Also collected in wet-weather pools near Charleston and Oilfield.

Rivulariaceae

Calothrix Kawrayskii Schmidle.
Common as an epiphyte on green algae in Hodgen's and the Tile Factory ponds. Not previously recorded for North America. Fide Collins.

Calothrix stagnalis Gomont.
Common each year in the Charleston ponds. Fruits in September. Fide Collins.

Rivularia natans (Hedw.) Welw.
Found abundantly during autumn months in the east Big Four pond. Fruits in October and November. Vegetative period begins in July.

Flagellatae

Euglenaceae

Euglena deses Ehrenberg.
Common in streams carrying some sewage, usually scattered among masses of the viridis type.

Euglena oblonga Schmitz.
Very abundant at the Ashmore Ice pond, October, 1912.

Euglena sanguinea Ehrenberg.
Appearing at intervals of a year or more in a number of our larger ponds in such quantity as to produce a brick-red or blood red scum on the water.
Euglena spirogyra Ehrenberg.
Rare. Only a few scattered specimens have been recorded.
Euglena viridis Ehrenberg.
Probably the commonest form in polluted streams, ponds, and wet-weather pools. But it is difficult to be certain of the identification when the chromatophore is masked by other cell contents.
Phacus longicauda (Ehrenberg) Duj.
Rare in ponds.
Phacus pleuronectes (O. F. M.) Duj.
Periodically abundant in ponds.

Peridiniales

Peridiniaceae

Ceratium hirundinella (O. F. M.) Schrank.
Common at times in all the ponds of eastern Illinois from which I have collections.

Bacillariales

Bacillariaceae

Melosira varians Agardh.
A periodic constituent of the plankton in the streams of this region.
Meridion circulare (Grev.) Ag.
Occasionally very abundant in small ditches and stream pools.

Confervales

Confervaceae

Ophiocytium arbuscula (A. Braun) Rabenhorst.
Rare. Recorded from the pond southeast of Lerna, and a pool near Decker, Ind.
Ophiocytium cochleare (Eichwald) A. Braun.
Common in ponds during the colder months.
Ophiocytium gracilipes (A. Braun) Rabenhorst.
Rather rare in pools during the colder months of the year.
Ophiocytium parvulum (Perty) A. Braun.
Rather common in ponds and pools during late fall and early spring.
Conferva bombycina Agardh.
Very abundant in streams, ponds and pools. The form **tenuis** frequently occurs with it.

Conferva minor Klebs.
Very abundant in all aquatic habitats during open winter weather and the spring months.

Conferva utriculosa Kuetzing.
Not rare in ponds in the spring.

Botrydium granulatum (L.) Greville.
Apparently rare. Was found by Mr. T. L. Hankinson near Charleston in October, 1903.

Botrydium Wallrothii Kuetzing.
Very abundant on moist garden soil throughout the summer and autumn. Unlike Stichococcus flaccidus it grows in full sunlight. When the resting spores are formed it may assume a gray or reddish color.

Conjugales.

Desmidiaceae

Many species of Desmids occur in the collections, and the periodicity of some forms has been studied. It is hoped that by another year these collections will have been studied by some one competent to name them, and a list be ready for publication.

Zygnemaceae

Zygnema Collinsiana mss.
A new species remarkable for its blue spores, whose median wall is marked by large round pits. Found in association with Zygnema stellinum in the R. R. ditches between Oilfield and Casey. May, 1912.

Zygnema insigne (Hass.) Kuetz.
Common in pools, ditches, ponds, and small intermittent streams. Fruits in April and May.

Zygnema pectinatum (Vauch.) Agardh.
Very abundant in ponds and wet-weather pools. Fruits during April, May and June. Lateral conjugation has been observed in the east Big Four pond. Aplanospores and akinetes were produced abundantly in the spring of 1912.

Zygnema pectinatum anomalum (Rolfs) Kirchner.
Occurs with the type.

Zygnema pectinatum decussatum (Vauch.) Kirchner.
Not uncommon in ponds. As far as my observations go there is little reason for considering this a variety of **pectinatum.** In its distribution, behavior, and appearance it appears to be quite distinct.

Zygnema stellinum (Mueller) Agardh.
The most abundant of the Zygnemas of this region. It occurs in ponds, pools, ditches, and intermittent

streams. Fruits from March to May. Produced akinetes in 1912. Fide Collins.

Spirogyra areolata Lagerh.

Occurs in the pond west of Greenup, in the pond on the Brookhart farm southwest of Oilfield and Hodgen's pond.

Spirogyra catenaeformis (Hass.) Kuetzing.

Very abundant in pools, ponds, and small streams. Fruits during April, May, and June. Fide Collins.

Spirogyra circumlineata mss.

Resembles **varians,** but is considerablly larger. Found in Marshall pond during May, 1912.

Spirogyra communis (Hass.) Kuetzing.

Common in ponds and intermittent streams. Fruits from April to June.

Spiragyra condensata (Vauch.) Kuetzing.

Vegetative filaments apparently of this species have been found in several small streams and ponds. It has been found in fruit only once in Campus creek about one mile from the Normal school. The dimensions and appearance correspond closely to Petit's description.

Spirogyra crassa Kuetzing.

Rather frequent in ponds at Charleston, Ashmore, Casey and Newton. Dimensions often smaller than those given in Collins' Green Algae of North America. Fruits from May to July.

Spirogyra decimina (Mueller) Kuetzing.

Very generally distributed in streams and ponds. Fruits commonly during June, July and August. Fide Collins.

Spirogyra decimina triplicata Collins.

More abundant than the type. Frequently associated with it. Fruits about the same time. Fide Collins.

Spirogyra dubia Kuetz.

Found during the summer months in the Polk street pond, Charleston and the pasture ponds south of Ashmore.

Spirogyra fluviatilis Hilse.

Has been found fruiting in the Big Four ponds, Charleston, and in the Embarras river near Greenup, and Wheeler. The cells have three or four chromatophores and the spores have the median wall pitted. Fruits during the summer months.

Spirogyra gracilis (Hass.) Kuetzing.

Rare in swampy intermittent stream near Casey. Found fruiting in April.

Spirogyra Grevilleana (Hass.) Kuetzing.
Rather common in ponds, wet-weather pools, and streams. Fruits during April and May.

Spirogyra Hassallii (Jenner) Petit.
Rather rare in ponds near Charleston, Greenup and Casey. Fruits during April and May.

Spirogyra Illinoiensis mss.
A new form related to S. stictica. Differs in having larger dimensions, 6-8 chromatophores, and spores with the median wall punctate. Fruits in May. Known only from the pond southeast of Lerna.

Spirogyra inconstans Collins.
This species is abundant each year in a pond on the Brookhart farm about one mile southwest of Oilfield. It has also been found near Charleston and Lerna. Collins does not mention the fact that the mature spores have the median wall punctate. Fruits during May.

Spirogyra inflata (Vauch.) Kuetzing.
Very common in early spring in ponds, pools and ditches throughout eastern Illinois. Fruits in March and April.

Spirogyra inflata foveolata mss.
A new variety found in the Ice Plant pond, Casey, April, 1911. Differs from the type in having the median wall of the spore pitted.

Spirogyra jugalis (Dillw.) Kuetzing.
Recorded for the middle Tile Factory pond and a small pond north of Wrightsville. It probably occurs elsewhere in this vicinity. Fide Collins.

Spirogyra Jurgensii Kuetzing.
Common in ponds, pools, and streams. Fruits during April and May.

Spirogyra longata (Vauch.) Kuetzing.
Common, in ponds and pools. Fruits from April to June. Has been collected at Lawrenceville, Charleston, Paris, Westfield and Greenup. Fide Collins.

Spirogyra maxima (Hass.) Wittrock.
Rare. Recorded from ponds near Charleston.

Spirogyra narcissiana mss.
Found during September and October in fruit in the dam at Urban Park, west of Charleston. Vegetative cells somewhat like those of S. tenuissima, but the end walls are different, and the spores are formed without conjugation (aplanospores).

Spirogyra neglecta (Hass.) Kuetzing.
Rather common apparently in a vegetative condition, but

has been found in fruit rarely. Fruits in late spring and summer. Fide Collins.

Spirogyra nitida (Dillw.) Link.

Common in ponds throughout eastern Illinois. Fruits in summer and autumn. The dimensions are often smaller than those given by Collins. Our form corresponds closely to the description given by Hassall in his British Freshwater Algae.

Spirogyra orthospira Naegeli. **(Spirogyra Majuscula** Kuetz.)

Bottom land ponds and wet-weather pools. Common. Fruits from April to July. Fertile cells not infrequently inflated. Fide Collins.

Spirogyra Petitiana mss.

A species near **decimina.** Occurs only in the new Tile Factory pond, Charleston, but has been found for six years during the summer.

Spirogyra porticalis (Mueller) Cleve.

Very common in ponds, small and large streams. Beyond Charleston I have collected it at Lawrenceville, Olney and Paris. Fruits from March to May. Fide Collins.

Spirogyra punctiformis mss.

Found only in the Tile Factory ponds, Charleston. Near **punctata.** Differs in having one or two chromatophores, and larger dimensions.

Spirogyra quadrata (Hass.) Petit.

Collected in the new Tile Factory pond, Charleston.

Spirogyra setiformis (Roth) Kuetzing.

Common in ponds at Charleston and Ashmore. Fruits usually in late autumn. Spore wall hyaline showing the chromatophores within. Fide Collins .

Spirogyra Spreeiana Rabenhorst.

Rare in ponds near Charleston and Ashmore. Fruits during April and May.

Spirogyra stictica (Eng. Bot.) Wille.

Rather common. Has been collected in a fruiting condition at Ashmore, Sullivan and Casey. Fruits during April and May.

Spirogyra submaxima mss.

Has been collected annually in a pond east of Charleston. Near **maxima,** but has eight or nine chromatophores, spores smooth and with smaller dimensions.

Spirogyra tenuissima (Hass.) Kuetzing.

Very common throughout eastern Illinois, in ponds, pools and intermittent streams. Fruits in early spring.

Spirogyra tenuissima rugosa mss.

Rather frequent with the type. Medium spore wall minutely roughened.

Spirogyra varians (Hass.) Kuetzing.
The most abundant Spirogyra of eastern Illinois in the spring. Highly variable. Found in all aquatic habitats. Fruits from April to July.

Spirogyra Weberi Kuetzing.
Very common throughout eastern Illinois. Usually fruits in early spring. Found in all aquatic habitats.

Mesocarpaceae

Mougeotia Boodlei (W. & G. S. West) Collins.
Rather frequent in ponds. Fruits both sexually and asexually, in spring or fall or both. Fide Collins.

Mougeotia calcarea (Cleve) Wittrock.
Asexually fruiting material of this species was collected in the Ice Plant pond, Casey, April, 1911.

Mougeotia divaricata Wolle.
This species is common in the ponds near Charleston. It has been collected in a fruiting condition in summer and autumn. It fruits readily when brought into the laboratory.

Mougeotia genuflexa (Dillw.) Agardh.
Very common in ponds throughout eastern Illinois. Frequently found in a geniculate condition, but has been collected in fruit only during the spring of 1912.

Muogeotia genuflexa gracilis (Kuetzing) Reinsch.
Rare in wet-weather pools. Fruited in spring of 1912. Fide Collins.

Mougeotia quadrangulata Hassall.
Collected in a fruiting condition in Campus pond, the second Big Four pond, and the pools along the Clover Leaf R. R. north of Charleston, during the spring of 1912.

Mougeotia robusta (De Bary) Wittrock.
Common. Fruiting material has been collected in the pools along the Clover Leaf R. R. north of Charleston, and in Campus creek. Fruits in May and June.

Mougeotia robusta biornata Wittrock.
Common in Campus creek. Differs from the type in having a pitted median spore wall.

Mougeotia scalaris Hassall.
Has been collected in a fruiting condition in May in the middle Tile Factory and Marshall ponds.

Mougeotia Transeaui Collins.
Known only from the Embarras river near Greenup and the ponds near Charleston. Fruits both sexually and asexually, in fall or spring.

Mougeotia viridis (Kuetzing) Wittrock.
Collected in fruit in Campus pond, May, 1912.

Volvocales

Chlamydomonadaceae

Haematococcus pluvialis Flotow.
Apparently rare. Have noted typical specimens but once. These were collected from a small pool near Hodgen's pond.

Volvocaceae

Gonium sociale (Dujard) Warming.
Found in Urban Park pond, April, 1912.
Gonium pectorale Mueller.
Not infrequent in ponds and pools.
Pandorina Morum (Mueller) Bory.
Very common in the more permanent ponds of eastern Illinois. Very conspicuous in low water stages--probably through concentration.
Pleodorina illinoisensis Kofoid.
Found in Little Muddy creek, north of Sailor Spring, August, 1911.
Eudorina elegans Ehrenberg.
Appears rather regularly in ponds during mid-summer.
Volvox globator Linnaeus.
This species has been collected in the Ice Plant pond at Casey and in a roadside ditch near Decker, Indiana.
Volvox aureus Ehrenberg.
Collected but once in the west Tile Factory pond, Charleston, July, 1911.
Ineffigiata neglecta W. & G. S. West.
Very abundant in the plankton of the ponds of eastern Illinois.
Tetraspora lubrica (Roth) Agardh.
Very abundant in streams and ponds during the autumn, winter and spring. The fronds not infrequently attain a length of four feet. Fide Collins.
Tetraspora gelatinosa (Vauch.) Desvaux.
Collected only once in a pond near the reservoir at Casey, Sept., 1911.
Apiocystis Brauniana Naegeli.
Collected at Marshall pond north of Charleston in April, 1912.

Protococcales

Protococcaceae

Chlorochytrium Knyanum Cohn & Szymanski.
Very abundant in the leaves and stems of Nasturtium

lacustre in the pond southeast of Lerna, May, 1912. Lerna, May, 1912.

Scenedesmaceae

Zoochlorella conductrix Brandt.
Occurs abundantly associated with the green Hydra and Paramoecium bursaria.

Zoochlorella parasitica Brandt.
Found in the west Big Four pond, Charleston, in the fresh water sponge.

Raphidium falcatum (Corda) Cooke.
A common constituent of the pond plankton.

Oocystis solitaria, forma **major** Wille.
Common in the ice plant pond at Casey.

Gloeotaenium Loitlesbergerianum Hansgirg.
Has been collected in Hodgen's pond, the middle Tile Factory pond, and the east Big Four pond, near Charleston. Occurs from June to October. Consists of single cells and 2-, 4- and 8-celled families. The life history of this peculiar form has been described in the Botanical Gazette, Jan., 1913.

Nephrocytium Agardhianum Naegeli.
Common in all of the more permanent ponds.

Scenedesmus bijuga (Turp.) Wittrock.
Very common in the plankton of ponds. This and the following species multiply rapidly in laboratory aquaria and color the water a bright green. Species of **Rhaphidium** are commonly associated with them.

Senedesmae bijuga alternans (Reinsch) Hansgirg.
Occurs with the type.

Scenedesmus obliquus (Turp.) Kuetzing.
Found in plankton from the Lily pond on the campus.

Scenedesmus quadricauda (Turp.) Kuetzing.
Very common. Along with the type I have noted the forms **setosus, abundans,** and **horridus** of Kirchner.

Crucigena rectangularis (A. Braun) Gay.
Abundant in the east Big Four pond during September, 1911.

Selenastrum acuminatum Lagerheim.
Not infrequent in plankton from ponds.

Kirchneriella lunaris (Kirchner) Moebius.
Very rare.

Coelastrum cambricum Archer.
Seen in material from the Lily pond on the Campus, and the pond at Urban Park, Charleston.

Coelastrum microporum Naegeli.
Very abundant in most of our ponds.

Sorastrum spinulosum Naegeli.
Frequent in most of the permanent ponds.

Hydrodictyaceae

Hydrodictyon reticulatum (L.) Lagerheim.
A common plant in the town branch and the bottom land ponds near Newton. My records of its occurrence extend from May to September.
Pediastrum angulosum (Ehrenberg) Meneghini
Rare in the plankton of ponds.
Pediastrum Boryanum (Turp.) Meneghini.
Very abundant.
Pediastrum duplex Meyen.
Very abundant.
Pediastrum duplex clathratum A. Braun
Common with the type.
Pediastrum tetras (Ehrenb.) Ralfs.
Rare, among other species.

Ulotrichales

Ulotrichacae

Ulothrix variabilis Kuetzing.
A common form in pools and permanent streams. In the pools along the Big Four R. R. it is commonly accompanied by its hormospora form. This seems to be the only species of Ulothrix in this part of the state.
Schizomeris Leibleinii Kuetzing.
Rather rare in streams and ponds. Near Charleston it has been noted in Hodgen's pond, the campus Lily pond and Campus creek. It also occurs in the town branch, near Effingham. Most abundant in the summer and autumn.
Stichococcus bacillaris Naegeli.
The form **confervoideus** is probably common in intermittent streams, pools and swamps in early spring. Fide Collins.
Stichococcus flaccidus (Kuetzing) Gay.
Very common on shaded moist ground. Frequently associated with moss protonemata especially of Funaria and Pottia. Fide Collins.
Stichococcus subtillis (Kuetzing) Klercker.
Abundant in early spring in pools and intermittent streams.
Microspora stagnorum (Kuetzing) Langerheim.
Very abundant in ditches, pools, and intermittent streams in late autumn, during winter thaws, and in early spring. Fide Collins.

Microspora tumidula Hazen.
Found in an aquarium, the material having been collected from Hodgen's pond. Fide Collins.

Cylindrocapsaceae

Cylindrocapsa geminella minor Hansgirg.
Common in the ponds at Charleston and Ashmore. Vegetative material may be seen at all times. Fruiting occurs during June.

Oedogoniaceae

Oedogonium acmandrium Elfving.
Found in aquarium, material from Marshall pond, early spring, 1913. Dimensions slightly larger than those given by Hirn. Each antheridium produces a single sperm!

Oedogonium acrosporum De Barry.
The form **connectens** occurred in Marshall pond during May, 1912.

Oedogonium aster Wittrock.
This form is apparently the rarest of the spiny spored forms. It has been collected at Charleston and Greenup. The Charleston material has dwarf males with two antheridia!

Oedogonium Borisianum (Le Cl.) Wittrock.
Found at Marshall pond north of Charleston in May, 1912.

Oedogonium Boscii (Le Cl.) Wittrock.
Has been collected from the east Big Four pond, and the pond on the campus.

Oedogonium Brauni Kuetz. Pringsh.
Found in the pond just west of Greenup, along the Vandalia R. R.

Oedogonium cardiacum (Hass.) Wittrock.
Not uncommon. Has been recorded from ponds in the vicinity of Charleston, Greenup, Newton and Casey.

Oedogonium cardiacum carbonicum Wittrock.
Rather common in Marshall pond in May, 1912.

Oedogonium concatenatum (Hass.) Wittrock.
Collected at west Big Four pond, Charleston, May, 1911.

Oedogonium crassiusculum idioandrosporum Wittr. & Nordst.
Common in the more permanent ponds. Very irregular in its time of abundance and fruiting. Recorded from Charleston, Casey and Newton.

Oedogonium crassum amplum (Magn. & Wille) Hirn.
I have seen its vegetative filaments among other algae a number of times. It fruited in the east Big Four pond

during October, 1910. During October, 1912, I found it fruiting abundantly among some Azolla plants sent me from the Missouri Botanical Garden, St. Louis.

Oedogonium crenulato-costatum Wittrock.

Collected from the pond on the Normal School campus, and from a pond near Wheeler. In the first locality it was abundant on the crayfish living in the pond. Fruits in summer and autumn.

Oedogonium crenulato-costatum cylindricum Hirn.

Occurred during October, 1910, in the Ice Plant pond at Casey.

Oedogonium crispum (Hassall) Wittrock.

Rather rare. Collected in the pond near Lerna, and the Ice pond at Ashmore, during May, 1912.

Oedogonium cryptoporum vulgare Wittrock.

Found in the Ice pond at Casey and the pond southeast of Lerna.

Oedogonium cyathigerum Wittrock.

This species occurs in Hodgen's and Marshall ponds. Fruits during May, June and July.

Oedogonium echinospermum A. Baun.

Common in the spring of 1912 in wet-weather pools and ponds near Charleston, Ashmore and Oilfield.

Oedogonium Franklinianum Wittrock.

Recorded from Hodgen's pond, Campus pond, and the Tile Factory ponds, Charleston. Fruits in summer and autumn.

Oedogonium globosum Nordtstedt.

Very typical material has been collected from Marshall pond, Charleston and the Lily pond, southeast of Newton. Previously reported from the Hawaian islands and Massachusetts.

Oedogonium gacillimum Wittr. & Lund.

This form is common in ponds and pools. Recorded from Charleston, Dorans, Ashmore and Lerna.

Oedogonium grande Kuetzing.

This is the most common of the Oedogoniums in our streams. It also occurs in the more permanent ponds. It fruits at irregular intervals. It has been collected at Charleston, Greenup, Ashmore, Newton, Lerna and Humbolt in this state; and at Decker, Indiana. There are at least three varieties present in the local waters.

Oedogonium intermedium Wittrock.

This species has been previously known only from Europe. Our material, collected from the Marshall pond, Charleston, and Wolfe's pond, near Wheeler, approaches the form **valida.**

Oedogonium irregulare Wittrock.

This has been previously collected by Wolle in Florida. Here I have observed it only in Hodgen's pond fruiting in September.

Oedogonium macrandrium aemulans Hirn.

Found in the Ice pond, Ashmore, during October, 1912. Has been previously reported from Pennsylvania and California.

Oedogonium Magnusii Wittrock.

Rather common. Recorded from the Tile Factory ponds, railroad pools, Charleston, and the Ice pond, Ashmore. Distinguished by the pitted median membrane of the oospore from others of about the same dimensions. Associated commonly with Oe. rufescens.

Oedogonium multisporum Wood.

Common in small streams, occasionally found in ponds and pools. Usually fruits in May and June. Recorded from Butler's creek and first Tile Factory pond, Charleston, the pond north of Wrightsville, and the railroad pool near Sullivan. Fide Collins.

Oedogonium oblongum Wittrock.

Not previously collected in North America. Here found associated with Confervas in pools along the Clover Leaf R. R. north of Charleston, October, 1910.

Oedogonium obtruncatum Wittrock.

A form evidently belonging here was collected in the east Big Four pond, November, 1912. The dimensions are slightly larger than those given by Hirn for the variety **completum.**

Oedogonium paludosum (Hass.) Wittrock.

Found in the pond near Lerna, in May, 1912. Reported by Wolle, from Pennsylvania.

Oedogonium paludosum parvisporum

Rather common in the remnants of old prairie ponds near Charleston. Fruits in April and May. Not previously reported from America.

Oedogonium plagiostomum Wittrock.

Collected from the middle Tile Factory, and west Big Four ponds near Charleston, during October, 1912. Of special interest is the presence of antheridial filaments. The extremes of the dimensions for the oogonium are slightly larger than those given by Hirn. Known previously only from Sweden and Denmark.

Oedogonium plagiostomum gracilius Wittrock.

Not uncommon during May and June. In addition to the Charleston ponds, I have collected it from the Lily pond, southeast of Newton. The dimensions are near-

est those given for Mexican specimens. Also reported from New York.

Oedogonium Pringsheimii Norstedtii Wittrock.

Has been collected both in spring and fall in small quantities during the past three years. A cosmopolitan species. Known in American from Greenland, Minnesota and California.

Oedogonium propinquum Wittrock.

Fruited during October, 1912, in the middle Tile Factory pond and the east Big Four pond. Our material is nearer the larger dimensions given by Hirn than the smaller. Not previously reported from America.

Oedogonium pseudo-Boscii Hirn.

Rather rare in the remnants of old prairie ponds. Fruits during April and May. Previously reported from Massachusetts. Fide Collins.

Oedogonium pungens Hirn.

Common during May, 1912, in permanent ponds, and pools on the prairie. Distinguished from Oe. echinospermum which also occurs here by its more rounded spores, and the smaller size of its vegetative cells in comparison with the oogonia. Previously reported from South Carolina.

Oedogonium pusillum Kirchner.

Common in ponds and streams. Has been collected on several occasions in fine fruiting condition, ranging from May to September. Not previously reported from America. Fide Collins.

Oedogonium rufescens Wittrock.

The most common of the smaller Oedogoniums. Occurs in ponds and temporary pools during April and May. Previously reported from New England. Fide Collins.

Oeogonium rufescens exiguum (Elfving) Hirn.

Not infrequently associated with the type. Not previously reported from America.

Oedogonium rugulosum Nordstedt.

Collected in May, 1912, from the Ice Plant pond at Ashmore. The oospore walls are very distinctly crenulate. No dwarf males were present in the material. The local specimens belong to the form minutum (Hansgirg) Hirn. Not previously reported from America.

Oedogonium sociale Wittrock.

Common in ponds. Collected once from a stream. Fruits during April and May. Not previously reported from America. Fide Collins.

Oedogonium suecicum Wittock.

Not uncommon in ponds and pools. Fruits during May. Previously reported from Massachusetts.

Oedogonium taphrosporum Nordstedt and Hirn.
Collected in the pond on the Normal School campus, July, 1912. Previously reported from Massachusetts.
Oedogonium tentoriale Nordstedt and Hirn.
Collected from the Tile Factory ponds, October, 1910. The dimensions approach the lower limits given by Hirn. Not known aside from the original station in Brazil.
Oedogonium Vaucherii (Le Cl.) A. Braun.
Common in summer and early autumn in ponds at Charleston and Ashmore. Reported from Massachusetts. Fide Collins.
Oedogonium Wolleanum Wittrock.
Common as scattered filaments among other algae during April and May in ponds. Widely distributed in the United States. Fide Collins.
Bulbochaete Brebissonii Kuetzing.
Abundant in west Big Four pond during May, 1911. Known from Massachusetts and Alaska.
Bulbochaete crassiuscula Nordstedt.
Common in pond southeast of Lerna during May, 1912. Previously known from Greenland and Massachusetts
Bulbochaete intermedia De Bary.
Collected during May, 1912, from Ice pond, Ashmore, and the Tile Factory pond, Arthur. Widely distributed in America.
Bulbochaete minor (A. Braun) Wittrock.
Collected from a pool in a swampy ravine bottom southeast of Decker, Indiana, May, 1911. Has been reported from New Jersey.
Bulbochaete rectangularis Wittrock.
Apparantly common in ponds during May. Reported from Pennsylvania and New England.
Bulbochaete varians Wittrock.
Collected from the pond on the campus, Charleston, and the pond southeast of Lerna, May, 1912. Not previously reported from America.
Bulbochaete varians subsimplex (Wittrock) Hirn.
Collected from the campus pond during October, 1911. Reported from Pennsylvania.

Chaetophoraceae

Microthamnion Kuetzingianum Naegeli.
Common in small streams during autumn and spring.
Microthamnion exiguum Reinsch.
A minute species with cells 1-2 microns in diameter. Collected at Marshall pond, Charleston, April, 1911.

Microthamnion strictissimum Rabenhorst.
Not infrequent in streams during the cooler months of the year.

Chaetosphaeridium globosum (Nordstedt) Klebahn.
Rather common in temporary ponds on submerged seed plants. Early spring.

Chaetophora elegans (Roth) Agardh.
A very common alga in ponds and streams, attaining its largest size and greatest abundance in the prairie ponds, during April and May.

Chaetophora incrassata (Huds.) Hazen.
Very common in pools, ponds and streams. Our largest specimens are less than eight centimeters in length. Usually associated with species of Draparnaldia.

Chaetophora pisiformis (Roth) Agardh.
The only collection containing material that could satisfactorily be placed here came from the Tile Factory pond, Arthur, May, 1912.

Stigeoclonium glomeratum (Hazen) Collins.
Rather common in ponds and pools during March and April.

Stigeoclonium lubricum varians (Hazen) Collins.
Our most abundant species of Stigeoclonium. Usually found in intermittent streams during the period from November to April. Also occurs in ponds, pools and ditches.

Stigeoclonium nanum (Dillw.) Kuetzing.
Recorded from Cut-off of Polecat creek near Ashmore, April, 1912.

Stigeoclonium stagnatile (Hazen) Collins.
Common in ditches and pools in early spring on the prairie.

Stigeoclonium tenue (Ag.) Kuetzing.
Rare in temporary ponds and pools, particularly the remnants of old prairie ponds.

Draparnaldia acuta (Ag.) Kuetzing.
Rare. Specimens that seemed best classified here have been collected from the east branch of Campus creek, and a small stream on the D. B. Miller farm southwest of Casey.

Draparaldia glomerata (Vauch.) Agardh.
Rare. Only recorded from a drainage ditch north of Paris.

Draparnaldia plumosa (Vauch.) Agardh.
This is the commonest species of the genus. It is very abundant in the streams particularly of the forested soils. It is common in the ponds both of the forested

and prairie areas. It is quite variable in form under these various circumstances. Fide Collins.

Draparnaldia Ravenellii Wolle.

Common in old prairie ponds, thus far not seen in the ponds of the upland forested region. It is common, however, in the bottom land ponds of the Wabash river south of Lawrenceville and Vincennes. This very distinct form has been known only from the collection made by Ravenel in South Carolina. The longest specimen noted attained a length of 27 centimeters. Fide Collins.

Pleurococcus vulgaris Meneghini.

Very abundant on slightly shaded rocks, trees and fences. Absent in forests.

Herposteiraceae

Herposterion confervicola Naegeli.

Common in ponds and pools on various filamentous algae.

Coleochaetaceae.

Coleochaete irregularis Pringsheim.

Rather common in temporary ponds. Fruits in late spring and summer.

Coleochaete Nittelarum Jost.

Found on Chara and Nitella in Hodgen's and the east Big Four ponds. Fruits in mid-summer.

Coleochaete orbicularis Pringsheim.

Collected from the pond at the west end of Polk street, Charleston, April, 1912.

Coleochaete scutata Briebisson.

Very common in ponds both permanent and temporary. Have found it fruiting sexually in late May and June.

Siphonocladiales.

Cladophoraceae.

Rhizoclonium hieroglyphicum (Ag.) Kuetzing.

Very abundant in streams and ponds. It is not unusual to find the prairie streams fairly choked with a growth of this alga in May and June. In the ponds it is commonly associated with species of Cladophora. Fide Collins.

Rhizoclonium fontanum Kuetzing.

Rather common in ponds. Have never found it in a branched condition. Occasionally it occurs on the moist soil of pond margins. Fide Collins.

Cladophora glomerata (L.) Kuetzing.

The common species of the streams of eastern Illinois.

Quite variable irrespective of habitat. It usually produces zoospores in spring and early summer, not infrequently also in the autumn. Specimens twenty feet in length have been found in Whetstone creek. Whether these were single plants in the strict sense could not be determined, but they had this appearance. Attached to rocks in a riffle, the long fronds floated down into an adjoining pool. Fide Collins.

Cladophora fracta (Dillw.) Kuetzing. Fide Collins.

Cladophora crispata (Roth) Kuetzing.

I have not been able to separate these two species in the field. If they are distinct they present a hopeless tangle for field study. They have been collected from most of the ponds that are permanent or nearly so. Fide Collins.

Pithophora Varia Wille.

Common in the permanent ponds. Produces akinetes at all seasons and ages of the plants. Fide Collins.

Siphonales.

Vaucheriaceae

Vaucheria geminata (Vauch.) De Candolle.

Vaucheria germitata racemosa (Vauch.) Walz.

Both the species and variety are abundant in the streams, ponds, pools and on moist shaded ground throughout eastern Illinois. Fide Collins.

Vaucheria hamata (Vauch.) De Candolle.

A small form of this species was collected from Polecat creek in the spring of 1911. Fide Collins.

Vaucheria polysperma Hassall.

Found in both the east and west Big Four ponds in the autumn.

Vaucheria sessilis (Vauch.) De Candolle.

Very abundant in all kinds of aquatic habitats. I have never found it growing on moist soil out of doors, though it grows commonly on soil in the greenhouse.

Vaucheria terreseris (Vauch.) De Candolle.

Common on prairie pond margins and shaded soil. Even in these situations it is less abundant than **Vaucheria geminata.**

Rhodophyceae

Batrachospermum Boryanum Sirodot.

Common in the town branch at the eastern edge of Charleston, and in Polecat creek south of Ashmore. I have not seen any fruiting material. Fide Collins.

THE SEXTON CREEK LIMESTONE IN ILLINOIS

T. E. SAVAGE

A NEW SPECIES OF MARIONINA FROM ILLINOIS.

FRANK SMITH and PAUL I. WELCH

A BLACK CROWNED NIGHT HERONRY AND NEED OF ITS PROTECTION.

CHARLES W. FINLEY

About a mile and a half from the old Worth race track and some fifteen miles from the down-town district of Chicago is a rookery of black-crowned night herons. This heronry is situated on a "tree island" of about four acres in what is known as the "Sag," the outlet of old Lake Chicago. Surrounding it on three sides is farm land and on the fourth is a large marsh.

The number of birds using the heronry has been estimated from 600 to 1,000. Although it is located in a secluded place it happens to be within the confines of a Chicago gun club and each year increasing numbers of men are learning of its location. At present no permanent means of protection is afforded this valuable natural asset. That such protection is needed is shown by the fact that in frequent trips there in the last three years during the breeding season, I have never failed to find birds apparently shot. On one occasion, R. Chaney of the University of Chicago and myself found a pile of about 20 birds both adults and immature. A unique "hunting match" is reported to have been held there a few years ago in which the farmer sportsmen of the community stationed themselves at the edge of the grove and killed the birds as they were scared out by the boys.

That this bird is rare is known by most of us and is shown by Barrows (Michigan Bird Life, 1912) who quotes the following from Swales, "It is now a rare bird and seldom recorded. In 1904, May, 5, one was taken at St. Clair Flats, and on July 16, I saw one near the River Rouge."

Because of the flats, farm land and marsh surrounding it, because of its size and because of its isolation the place lends itself to protection. Because the birds are wantonly killed and because they are rare they deserve our protection. It is with the hope that this society might see fit to take a hand in the conservation of this rare natural phenomenon that this paper is presented.

REPRODUCTION BY LAYERING IN THE BLACK SPRUCE.

GEORGE D. FULLER

During the summer of 1912 while conducting some ecological studies along the Saguenay River, Quebec, attention was directed to the process of forestation and reforestation of slowly disintegrating granitic areas and where the rocky surface was exposed to the full sweep of the wind. The region most closely examined consisted of granite hills about Ha! Ha! Bay with typical roches mountonnees contours and elevations varying from 100 to 300 meters. In these exposed situations the tree vegetation consisted largely of black spruce, Picea mariana, Jack pine, Pinus Banksiana, the white birch, Betula alba and the aspen, Populus tremuloides with accasionally some white spruce, Picea canadensis and a few other less abundant species. Many of the conifers exhibited a growth-form apparently peculiar to such areas and finding its highest specialization and most frequently occurrence in the black spruce.

Grown in swamps or thickets the black spruce is characterized by an irregular narow cone of branches. This cone was found to be even more slender in the sparse stand on the granite surfaces but here were found in addition much longer branches near the surface of the rock, forming a compact mass of twigs, none rising more than 1-2 meter above the surface. At least one half of the total foliage of the trees was usually upon these prostrate branches. The same habit was evident in Pinus Banksiana and to a less extent in Picea canadensis. It seemed a decided advantage to trees rooted in the shallow soil of the rock crevices as the exposure to excessive transpiration caused by high winds was much less, and fewer trees were uprooted. The habit was confined to open stands.

The mat of lichens and mosses which antedates the trees, continued to thrive under and among the prostrate branches and the resulting soil soon buried portions of the lower members of the mass. This was apparently without results other than somewhat more securely anchoring the trees in the case of Pinus Banksiana but on the spruces roots were often produced from the buried branches and a circle of young trees surrounded the parent. Should the tree be cut down its early replacement was assured from this layering.

Such reproduction by layering has recently been discussed by Cooper(1) who has also given complete citations of the literature of the subject. The layering habit in Picea mariana is mentioned by Louden(2) for specimens growing under partial cultivation on the British Isles but its effect in

increasing the stand upon rocky areas appears to have escaped notice, although it must be of much importance to the species. By it circular areas with a radius of six to ten feet soon become covered with vigorous young upright shoots. The change in direction of growth of the stem axis is strongly marked and seems to be closely connected with the process of rooting although not always dependent upon it.

In the Saguenay region occasional instances of layering were seen in Picea canadensis, Cooper's observations were confirmed on Abies balsamea but by far the most important from the ecological viewpoint was its abundance in the black spruce. Often large clumps of small trees could be referred to the parentage of a few individuals although with increase in size the connections became increasingly difficult to trace. Frequently groups of six to twenty closely clustered young trees marked the spot where a tree of an older generation had stood showing much more rapid replacement than could have been effected by seed.

University of Chicago.

(1) Cooper, W. S. Reproduction by layering among conifers. Bot. Gaz. 52: 369-379. 1911.

(2) Louden, J. C: Arboretum et Fruiticetum Britannicum. London, 1844.

EVAPORATION AND SOIL MOISTURE ON THE PRAIRIES OF ILLINOIS.

E. M. HARVEY

I. Introduction.

The prairie association is quite common in the Chicago region, where it occurs both as small isolated patches and in rather extensive and continuous areas. The association seems to hold here, at least, the position of a very persistent stage in the succession following the sedges in the filling up of ponds and lakes. (1) Although it is to be considered as decidedly different in many ways from the Western prairies, it gives very much the same aspect, this being emphasized by the characteristic coarse prairie herbs such as species of Rudbeckia, Liatris and Amorpha together with Solidago rigida, Eryngium yuccifolium, Silphium laciniatum, S. terebinthinaceum and others that occur here. Whatever may be the final history of these prairies as regards succession, it is noteworthy that they are maintained for extended periods against the encroachment of the forests of the region.

Since the above general problem, and others are presented by these edaphic prairies, it seems highly desirable that any quantitative measurements of environmental factors be brought forward.

During the summer of 1911 a series of evaporation and soil moisture determinations were carried out at Chicago Lawn, an undisturbed prairie area within the city limits of Chicago. The work was made to conform more or less with similar, though more extensive studies of Fuller (2) on the forest associations of the south shore dune region of Lake Michigan, and those of McNutt and Fuller (3) on the oak-hickory forest at Palos Park, Ill.

II. Evaporation.

Evaporation determinations were made by means of the Livingston standard atmometer (4) and the methods of operation suggested by him were carefully followed. During the early part of the season, including the months of May and June, the cups were equipped with the rain-correcting device.(5)

Two stations were established and maintained throughout the season, while at times, three, and during one week, four stations were in operation. The two principal stations, Nos. one and two, were located in the midst of the association, about 250 meters apart, the instruments being placed in similiar relation to the vegetation with the cups just below the general level of the grasses at a height of about 30 cm., above the surface of the soil. During the latter part of the season a third instrument was set up with the cup placed about 25 cm., above the level of the surrounding vegetation (i. e. about 60 cm. above the surface of the soil). Readings were made at intervals of one week or ten days throughout the season. The average daily loss for the intervening days was computed from these data. And finally the mean was taken from the results of stations one and two.

The records show the maximum evaporation, for the season, of 37 c. c. per day to occur about the 20th of May. This extreme rate of evaporation might be considered very abnormal on the supposition that May 1911 was an unusually hot and dry month, as noted by McNutt and Fuller (3) in their work of the same spring. However, Miss Newlon finds the same situation in her studies on Chicago Lawn during the season of 1912. It seems not improbable that this high rate of evaporation is the usual condition at the beginning of the season before vegetation becomes well developed, and may be a factor of considerable importance in the growth of these plants. An examination of graph **a**, fig. 1, will show the presence of two summer maxima, one in July, of 15.8 c. c. per day, and the other in August, of 16.0 c. c. per day. The minimum evaporation recorded is 5.9 c. c. per day, occuring in the latter part of September. The mean daily rate for the entire season of 168 days is 12.5 c. c. Also from fig. 1**b**, it

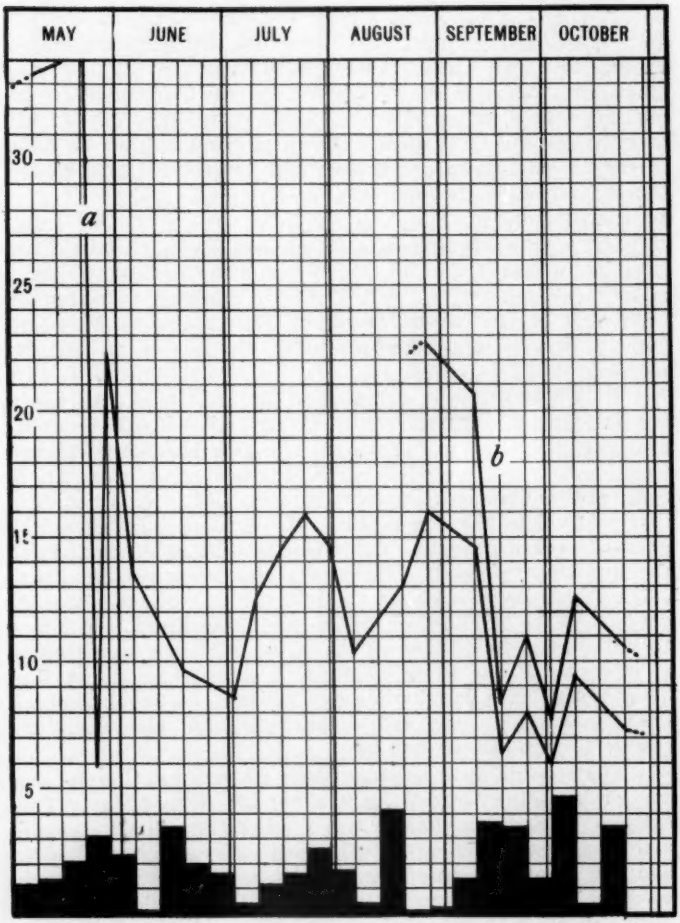


Fig. 1. Graphs showing the evaporation on the prairie, summer 1911. **a**:. Mean at stations 1 and 2. **b**: at station 3, cup above vegetation. Weekly rain-fall in cm. shown at base of figure.

may be seen that station 3, the one having the cup above the vegetation, gave the same fluctations as did the other stations and differed only in that the rate for each period was always 25 to 30 per cent greater.

It may be instructive to compare the results here with

those reported by Fuller (2) for the cottonwood dune, the pine dune, the oak dune and the beech-maple forest, and also those of McNutt and Fuller (3) for the oak-hickory forest. Though the figures themselves are not repeated, fig. 2 will show the relative average evaporation of these different associa-

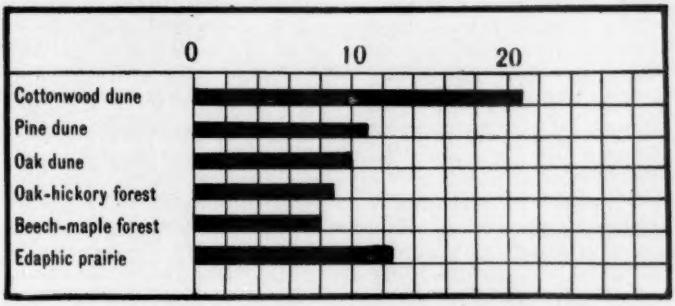


Fig. 2. Diagram showing average daily rates of evaporation in various plant associations of the Chicago region.

tions. It is evident at once that the evaporation conditions of this edaphic prairie are between those of the cottonwood dune and the pine dune, though more nearly equivalent to the latter. But the summer maximum of evaporation on the prairie is as low as the corresponding maximum of any of the forest associations yet studied in this region, excepting the beech-maple forest which has a maximum of only 13.2 c. c. per day. It corresponds rather closely in this respect to the pine dune, the oak dune, and the oak-hickory forest that has not been pastured. It seems somewhat surprising that the summer maximum on this prairie should be found so low as compared with the forest types, considering how slight is the apparent protection here from wind and sun. So the results would tend to show that, contrary to what one might expect, there must be a considerable resistance offered by the covering of grasses to the movement of air, this becoming evident in the stratum in which the cups were placed. The moist air blanket, thus tending to develop among and just above the grass covering, would largely account for the rather unexpected low summer maximum rate of evaporation.

III. Soil moisture.

The determinations of the water content of the soil were made weekly from April 11 to October 25 from samples of about 200 grams taken at the depth of 7.5 cm. and 25 cm. at each of the stations 1 and 2. The soil was brought into the

laboratory in sealed vessels and dried at 104 degrees, C. The percentage of water was calculated in terms of the dry weight of the soil.

Since the mere knowledge of the water content of the soil is of little value toward the understanding of the real water conditions to which the plant is being subjected, it becomes necessary to relate such facts to the plant directly in some manner that they may be at all significant. On the whole, the most satisfactory methods yet devised for getting at this difficulty are probably those described by Briggs and Shantz, (6) by which they were able to show a definite relation between the plant and the water content of any given soil. Their method of determining the wilting coefficient directly, by the wax seal method, and indirectly by means of the centrifuge, etc., are now well known. However, it may not be amiss to recall that in one of their indirect determinations of the wilting coefficient they employed the following formula which they found to hold, apparently, for all types of soils investigated. (*)

Wilting coefficient equals moisture equivalent divided by 1.84. The moisture equivalent here being that amount of water which the soil has the power of holding against a given high centrifugal force. The number 1.84 is a constant.

In the autumn of 1912 a centrifuge of the type used by the government workers in the soil investigations was installed in the Botanical laboratory. By means of this apparatus the moisture equivalents of the various soils brought in from Chicago Lawn were determined. The force used was always 1,000 gravities, acting during 30 minutes.

By the above method the soils of the two stations were found to have the following wilting coefficients: station 1, the 7.5 cm. depth, 28 per cent and the 25 cm. depth, 20 per cent; station 2, the 7.5 cm. depth, 23 per cent and the 25 cm. depth, 19 per cent.

Fig. 3 gives the graphs of the water content of the soils from station 1 for the entire season, plotted with percentage of water as ordinates and weekly intervals as abscissae. The soil at the 7.5 cm. depth represented by graph **a**, and at 25 cm. by graph **b**. The horizontal dotted lines, **c** and **d**, mark the wilting coefficients of these soils respectively, as calculated by the method described. The water content and the wilting coefficients of the two soils of station 2 are represented in fig. 4, exactly in the manner as are those of sta. 1, in fig. 3.

(*) For important contrary data see Caldwell, J. S. The relation of environmental conditions to the phenemonon of permanent wilting in plants. Physiol. Researches 1:1-56, 1913.

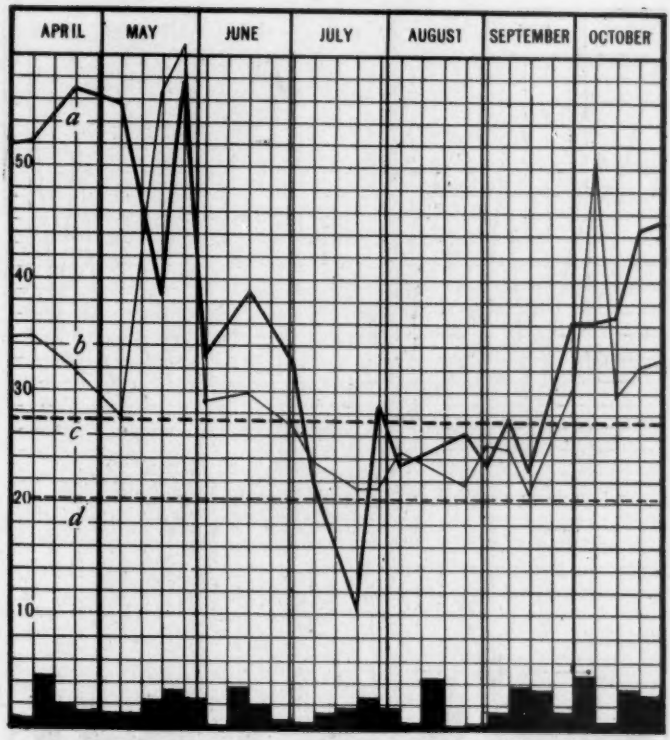


Fig. 3. Graphs showing soil moisture at station 1. **a**: of soil at the 7.5 cm. depth. **b**: of soil at the 25 cm. depth. **c**: wilting coefficient for the former and **d** for the latter soil. Weekly rain-fall in cm. shown at base of figure.

It will be noted from the graphs that the soil held large amounts of water until late in May when the content fell off rapidly during the rest of the month. This fall coincides with the high rate of evaporation already discussed for May. The general high water contents are at or near the saturation point, and this condition prevails in May, just before the growing season begins, and again in October after it has closed. In the summer months of July and August the moisture is uniformly low, giving a mean for those months of 24 per cent. There are times during these months that the water content of the soils at the two depths falls below the critical percentage. This is shown for example by the surface soil at station 1 (fig. 3) in July and August and by the deeper layer

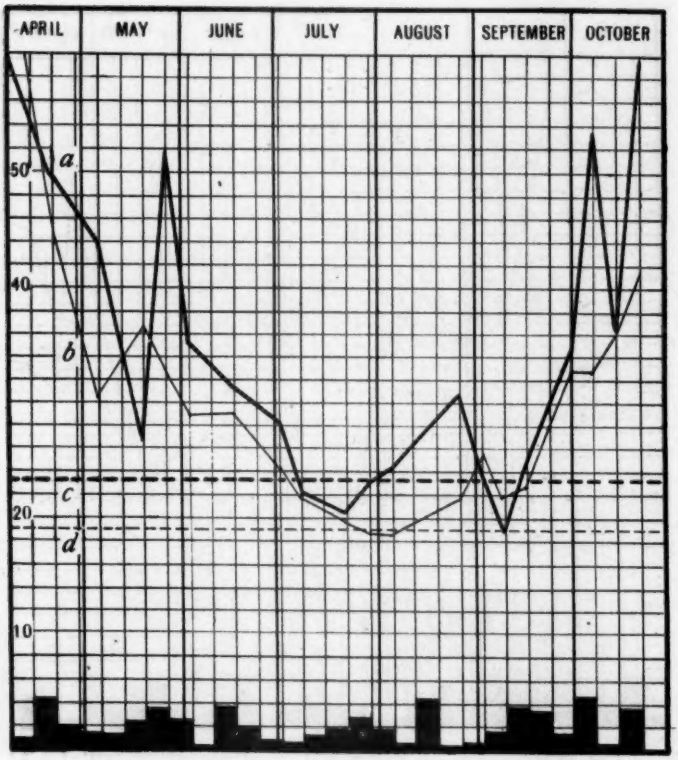


Fig. 4., Graphs showing soil moisture at station 2. **a**: of soil at the 7.5 cm. depth. **b**: of soil at the 25 cm. depth. **c** and **d** the respective wilting coefficient of these soils. Weekly rain-fall in cm. shown at base of figure.

of soil at station 2 (fig. 4) in July. It would also be well to note that at neither of the stations, except in the instance mentioned above, did the water content, at the depth of 25 cm. fall below the critical percentage. However, there must be many days at this period of the summer when the combined action of low water content of the soil and the high rate of evaporation render conditions very severe even for the characteristic vegetation of the association. This may account for the xerophytic aspect of the prairie vegetation in the late summer.

IV. Summary.

This paper presents evaporation and soil moisture records from the edaphic prairie association of the Chicago region for the growing season of 1911.

The data shows a very high rate of evaporation in May, before the grass covering has become developed.

The summer maximum rate of evaporation (i. e. when the grass covering is present) seems lower than that which one might expect, when compared with corresponding data trom forest associations.

The mean daily rate of evaporation for the season places the prairie association between the pine and the cottonwood dunes, as regards the atmospheric condition.

Through the summer months the water content of the soil is uniformly low, especially in the surface layer where it often falls below that percentage designated as the wilting coefficient.

On the whole, the data seems to indicate decidely severe mid-summer conditions in the prairie association.

Grateful acknowledgement is made of helpful suggestions from Drs. H. C. Cowles and Geo. D. Fuller during the progress of the study.

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Legend to figures:

THE STRATIFICATION OF ATMOSPHERIC HUMIDITY IN THE FOREST.

GEORGE D. FULLER, J. R. LOCKE and WADE McNUTT.

It has long been know that the air among the tree-tops of a forest has greater evaporating power than that just above the soil beneath, principally because of the fact that the upper air is subject to so much more movement and to more direct insolation. Up to the present time few or no attempts have been made to determine in a quantitative manner how great these differences really are for different forests and for different strata in these forests. The Livingston atmometer now provides an efficient means of making such determinations and hence during the spring of 1912 a beginning was made by two students of the Department of Botany of the University of Chicago, Mr. Locke working in a flood plain forest along the Vermilion River, near Streator, Illinois, and Mr. McNutt in an upland oak forest at Palos Park, near the city of Chicago,the same in which some former evaporation studies had been made (1). For several reasons, principally on account of the closing of the school year, the records are brief but both continue for some ten days after the trees were in full foliage and hence give some hint of the amount of difference of the evaporating power of the air in the different strata concerned. They are reported principally with the hope of stimulating further research upon this and similar problems.

The Streator forest was of the usual flood plain type with an abundance of Acer Negundo, Ulmus americana, and Fraxinus americana. Two stations, 0 and 1, were placed upon the surface of the soil, the first being at high water mark and the other some 60 meters farther from the river on gently rising ground, both being within the forest. The other instruments, designated as 3, 5, and 8, were placed in conditions of average shade and foliage at 3, 5 and 8 meters respectively above the surface. The period of experimentation extended from May 2 to June 5, 1912. The readings were standarized in the usual way (2), by means of the coefficients of the atmometer cups, the results reduced to the average loss per day for the intervals between the weekly readings and plotted as graphs with the weekly intervals as abcissae and the losses per day as ordinates (Fig. 1.). It will be seen that in general the results are that the evaporation at 3, 5, and 8 meters is very similar and is practically double of that upon the ground (o).

The forest at Palos Park is of the usual upland oak type. It has been more fully described in a previous paper (1). Here four stations were established, one upon the

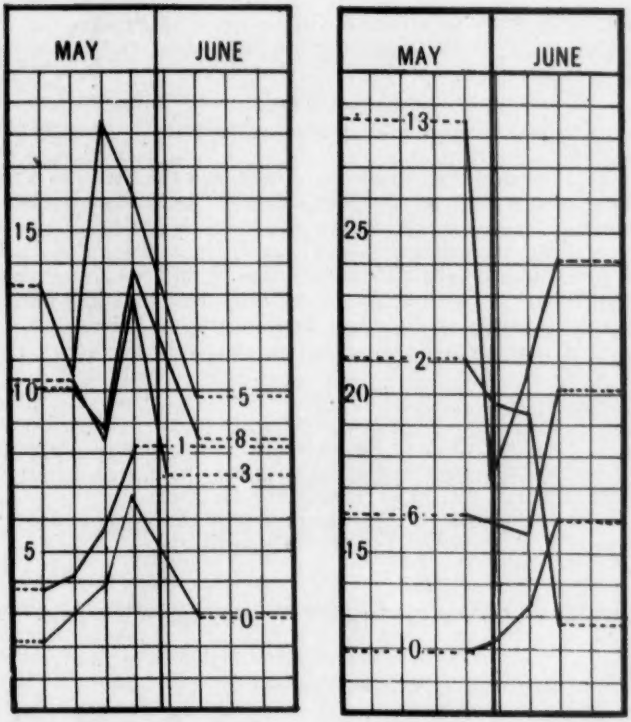

Fig. 1. Graphs showing the range of the evaporating power of the air in a flood plain forest at Streator, Ill. Figures at the right indicate the height of the station above the surface of the soil.

Fig. 2. Graphs showing the range of the evaporating power of the air in the oak forest at Palos Park, Ill.

ground, 0, the others at heights of 2, 6, and 13 meters. The last was at the general upper surface of the foliage while the others were carefully placed so as to be subject to very nearly average conditions of foliage density for their respective heights above the surface. The records extend from May 18 to June 12, 1912. The readings are expressed as in the former study. It will be seen by comparison that in general the rates of evaporation are much higher than in the Streator forest, reaching 16 cc. per day for the surface station at the end of the period and about 24 cc. per day for the upper surface of the forest foliage at the same

date. (Fig. 2). No attempt will be made to explain the irregular course of the graph for the instrument at 2 meters.

Summary:

1. The results are too scanty to permit of any generalizations.

2. The evaporating power of the air in the Streator flood plain forest within the medium strata of the foliage is about double of that upon the surface of the soil beneath.

3. The evaporating power of the air in the Palos Park oak forest at a height of 6 meters, that is, in a medium stratum of foliage, is greater by 25 per cent than that just above the surface while at the upper limit of foliage (13 meters) it is 50 per cent greater than that just above the surface of the soil.

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DISTRIBUTION OF FISH IN THE STREAMS ABOUT CHARLESTON, ILLINOIS.

T. L. HANKINSON.

Introduction:

The object of this paper is to give a list of the fish known to occur in the streams about Charleston, Illinois, with notes on their distribution, obtained by some ten years of field work in the region by the writer. Use will also be made of data bearing upon fishes of these streams given in the published work on the Fishes of Illinois by S. A. Forbes and R. E. Richardson. The terminology and order of consideration of species used by these writers will be followed in this paper. The fish collections made by the writer and from which the major part of the information here presented was obtained, are all preserved in an accessible condition in the zoology laboratory of the Eastern Illinois Normal school at Charleston. The species determinations have been made by the writer with the assistance of Mr. R. E. Richardson in the case of some forms difficult to identify. For this and other help given by members of the State Laboratory of Natural History, the author is duly grateful.

The streams, the fish life of which is to be considered.

are in Coles county and are accessible within a radius of fifteen miles of Charleston. They belong to the Embarras, the Kaskaskia, and Little Wabash systems, but chiefly to the first mentioned. They lie in country principally of two kinds: level black-soil prairie and rough, commonly hilly territory with light-colored soil and with patches of timber. Country of this last type prevails east and south of a diagonal line across Coles county from the northeast to the southwest corner. Streams of the Embarras and Little Wabash systems are associated chiefly with the hilly country and those of the Kaskaskia with the prairie. The Shelbyville Moraine crosses the southern part of the county and occupies most of the region just south of Charleston. In the north part of Coles county, there are some low prairie ridges that are associated with the Cerro Gordo Moraine. All the region under consideration is in the Wisconsin Glaciation, Coles county being on the southern border.

Based chiefly on size, the streams about Charleston may be fairly well grouped as follows:

1. **Streams of first rank or "Rivers."** These are Embarras and Kaskaskia rivers. In general, they average near a hundred feet in width with a common depth of three or four feet under ordinary water conditions. Except in deep holes, having much fine sediment, the bottom is usually gravelly or sandy with a thin superficial layer of clay.

2. **Streams of second rank or "Large Creeks."** This group includes the lower portions of Kickapoo Creek, Brush Creek and Polecat Creek. These never become dry, and they maintain a permanent connection with larger streams. They average in width between fifty and seventy-five feet and in depth, perhaps two or three feet.

3. **Streams of the third rank or "Small Creeks."** Among these, are the upper portions of those of the second group, as well as Cossel Creek, Indian Creek, Campus Creek, Crabapple Creek and Flat Branch. They never or very rarely become perfectly dry, although they frequently break their connections with parent streams by losing their water on reaching the flood plains of these streams to which they are tributaries. In dry seasons, they become broken into series of disconnected pools. Except during freshets, they are commonly five to fifteen feet in width and from one to two feet deep, rarely, even in "holes" exceeding three feet.

4. **Streams of the fourth rank.** These are the smallest fish-containing streams and are frequently referred to as "branches." There are many of these in the Charleston region flowing into all the other types and forming their headwaters. A number of them are at the bottoms of wooded

ravines and they constitute the smaller drainage ditches of the prairies. They are usually under four or five feet in width and they may be but a few inches wide. The depth is seldom over a foot. They are active for short periods except during unusually wet seasons. Many of them never contain fish.

The following table shows the distribution of the common species of fish in the Charleston region in the four types of streams just described.

Table Giving Distribution of the Thirty-eight Common Species of Fish in the Charleston Region

	First rank streams.	Second rank streams.	Third rank streams.	Fourth. rank streams.
Chub Sucker			X	
Common Sucker		X*	X	
Hog Sucker	X	X*		
Common Redhorse	X*	X		
Common Carp	X			
Stone-roller	X	X	X	X
Silvery Minnow			X	
Black-head Minnow			X	
Blunt-nosed Minnow	X*	X*	X	
Horned Dace	X	X	X*	X
Bullhead Minnow	X			
Straw-colored Minnow	X*	X		
Notropis illecebrosus	X*	X		
Silverfin	X*	X	X	X
Common Shiner	X	X	X*	X
Blackfin	X*	X*	X	
Silver-mouthed Minnow	X*	X*	X	
Sucker-mouthed Minnow	X	X*		
Big-eyed Chub	X*	X		
Storer's Chub	X			
River Chub	X	X	X*	
Channel Cat	X*	X		
Yellow Bullhead	X*	X	X	
Black Bullhead	X*	X	X	
Brindled Stonecat	X*	X		
Top Minnow	X	X*	X	
Brook Silversides	X			
Rock Bass	X*	X		
Blue-spotted Sunfish	X	X	X*	X
Long-eared Sunfish	X*	X	X	
Large-mouthed BlackBass	X*	X	X	
Small-mouthed BlackBass	X	X*		
Hadropterus phoxocephalus	X			

	First rank streams.	Second rank streams.	Third rank streams.	Fourth. rank streams.
Black-sided Darter	X*	X		
Green-sided Darter	X*	X		
Johnny Darter	X*	X	X	
Sand Darter	X			
Rainbow Darter	X*	X	X	

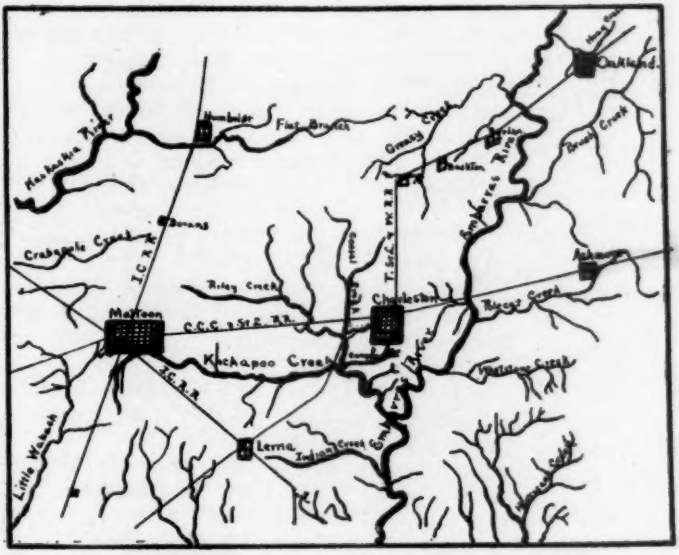
Note: X in the above means that the species is common in the type of stream, at least at some places and at some times.

* Indicates the type or types of stream where the species appears to be best represented.

List of Fish Known to Occur in the Charleston Region with Notes onTheir Numbers and Distribution.

1. **Lepisosteus osseus** (Linnaeus), Long-nosed Gar.
   Occasionally taken from the Embarras River. One seen in Kickapoo Creek in June 1907. Forbes and Richardson record it from the Kaskaskia system in Coles Co.
2. **Amia calva** Linnaeus, The Dogfish.
   Apparently scarce. Sometimes caught by hook from the Embarras River.
3. **Dorosoma cepedianum** (Le Sueur), Gizzard Shad.
   Reported for the Kaskaskia system in Coles Co., by Forbes and Richardson. Judging from fishermen's reports, it is probably in the Embarras River.
4. **Carpiodes difformis** Cope, Blunt-nosed River Carp.
   A few specimens have been taken from the Embarras River and from Kickapoo Creek. Forbes and Richardson report it from the Kaskaskia system.
5. **Carpiodes velifer** (Rafinesque), Quillback.
   Some small specimens have been taken from the Embarras and Kaskaskia Rivers and from Kickapoo Creek. Apparently uncommon.
6. **Erimyzon sucetta oblongus** (Mitchell), Chub Sucker.
   Prefers deep pools in small creeks where many are often found. Not often taken in the larger streams.
7. **Minytrema melanops** (Rafinesque), Spotted Sucker.
   Frequently taken in the Kaskaskia system; scarce in the Embarras system. Seems to prefer the larger streams.
8. **Catostomus commersonii** (Lacepede), Common Sucker.
   Locally common. Young numerous in a few creeks both large and small. Adults have been found in numbers only in Kickapoo Creek.
9. **Catostomus nigricans** Le Sueur, Hog Sucker.
   Very common on rocky shoals where the water is rapid, in rivers and large creeks.

10. **Moxostoma aureolum** (Le Sueur) Common Red-horse.
Abundant in largerstreams: rivers and large creeks.
11. **Moxostoma breviceps** (Cope) Short-headed Red-horse.
Uncommon. Seemingly confined to rivers and large creeks.
12. **Cyprinus carpio** Linnaeus, European Carp.
Common in parts of the Embarras and Kaskaskia Rivers. No records for tributary streams.
13. **Campostoma anomalum** (Rafinesque), Stone-roller.
Abundant and very generally distributed in the Embarras system, preferring the smaller streams. No records have been obtained for the Kaskaskia system in Coles county.
14. **Hybognathus nuchalis** Agassiz. Silvery Minnow.
Abundant in the Kaskaskia system in small creeks. Very scarce in the Embarras system.
15. **Pimephales promelas** Rafinesque, Black-head Minnow.
Common in portions of some small creeks where the water is sluggish and where the banks are grassy and shelving. No records have been obtained for its occurrence in the Kaskaskia system from the writer's collections. Forbes and Richardson record it from that system.
16. **Pimephales notatus** (Rafinesque), Blunt-nosed Minnow.
Abundant and very generally distributed in all but the smallest fish-bearing streams. This is undoubtedly the best represented species of fish in numbers of individuals, found in the Charleston region.
17. **Semotilus atromaculatus** (Mitchill), Horned Dace.
Abundant and found in all types of fish bearing streams in the region. It prefers small creeks.
18. **Abramis chrysoleucas** (Mitchill), Golden Shiner.
Uncommon about Charleston, but sometimes found in small numbers about thick growths of aquatic plants.
19. **Cliola vigilax** (Baird and Girard), Bullhead Minnow.
Periodically abundant in some parts of the Embarras River, and a few have been taken from all parts of the stream where collecting has been thoroughly done. Common in the Kaskaskia River. It appears to be confined to these large streams for no specimens have been caught in their tributaries.
20. **Notropis cayuga** Meek.
Recorded from Coles county by Forbes and Richardson None have been found by the writer.
21. **Notropis blennius** (Girard), Straw-colored Minnow.
Quite common in the Embarras River and in its larger tributaries; none recorded from small creeks. It appears to be absent in the Kaskaskia system.



Principal streams in the vicinity of Charleston.

22. **Notropis illecebrosus** (Girard).
Common locally in the Embarras River and in large creeks connected with it. No record for the Kaskaskia system.

23. **Notropis hudsonius** (DeWitt Clinton), Spot-tailed Minnow.
One taken by the writer in Crabapple Creek, near Coles, Illinois. This is the only record for the region.

24. **Notropis lutrensis** (Baird and Girard), Redfin.
Rare. Only two taken from Flat Branch and one from Crabapple Creek.

25. **Notropis whipplii** (Girard), Silverfin.
Abundant at all times in rivers and larger creeks and at times of high water in small creeks.

26. **Notropis cornutus** (Mitchill), Common Shiner.
Uncommon except in a few localities. It was found in large numbers in Crabapple Creek near Coles and in a part of Polecat Creek.

27. **Notropis atherinoides** Rafinesque, Shiner.
Ocassionally taken in the Embarras River and in the Kickapoo Creek near the river. No records for the Kaskaskia system.

28. **Notropis umbratilis atripes** (Jordan), Blackfin.
Abundant in the Embarras and Kaskaskia Rivers and in the larger creeks connected with these rivers.
29. **Ericymba buccata** Cope, Silver-mouthed Minnow.
Abundant and very generally distributed in the rivers and all creeks but the smallest ones of both systems creeks. The adults prefer larger streams.
30. **Phenacobius mirabilus** (Girard), Sucker-mouthed Minnow.
Not common but frequently taken in the rivers and large creeks of both systems.
31. **Hybopsis dissimilis** (Kirtland), Spotted Shiner.
Very rare. Recorded for the region by Forbes and Richardson. None taken by the writer.
32. **Hybopsis amblops** (Rafinesque), Big-eyed Chub.
Quite common in the Embarras and Kaskaskia Rivers and in their larger tributaries. Avoids small creeks.
33. **Hybopsis storerianus** (Kirtland), Storer's Chub.
Abundant in the Embarras River, where it is often taken on worm-baited hooks. Not found in tributaries of this stream except near their mouths.
34. **Hybopsis kentuckiensis** (Rafinesque), River Chub.
Abundant in the Kaskaskia system. Only two have been found by the writer in the Embarras system. These came from Polecat Creek. Forbes and Richardson record it for the Embarras River in Douglas Co.
35. **Ictalurus anguilla** Evermann and Kendall, Eel Cat.
A catfish caught by hook in the Embarras River on July 1, 1912, by Mr. C. P. Lantz, answers the description of this species.
36. **Ictalurus punctatus** (Rafinesque), Channel Cat.
Abundant in the Embarras River, and found in some numbers in parts of its larger tributaries.
37. **Ameiurus natalis** (Le Sueur), Yellow Bullhead.
Frequently taken by hook from deep holes in the rivers and from similar places in creeks. Large numbers of the very young of this species are often found in small creeks. The adults prefer larger streams.
38. **Ameiurus melas** (Rafinesque), Black Bullhead.
Common especially in large streams. Distribution similar to that of natalis. The two species appear to be closely associated.
39. **Leptops olivaris** (Rafinesque), Mud Cat.
Found in small numbers in the Embarras and Kaskaskia Rivers.
40. **Schilbeodes gyrinus** (Mitchill), Tadpole Cat.
Found in small numbers in the Kaskaskia system. No records for the Embarras system.

41. **Schilbeodes nocturnus** (Jordan and Gilbert), Freckled Stonecat.
Very rare; only three taken; one from Kickapoo Creek, one from the Kaskaskia River and one from Flat Branch.
42. **Schilbeodes exilis** (Nelson), Slender Stonecat.
Very rare. One taken in the Kaskaskia River in Coles county, September 3, 1908, by the writer.
43. **Schilbeodes miurus** (Jordan), Brindled Stonecat.
Abundant in the Embarras system where the bottom is rocky. Confined to this stream and its larger tributries. No records for the Kaskaskia system.
44. **Esox vermiculatus** Le Sueur, Little Pickerel.
Frequently found in shallow bays of the Embarras River; none have been found elsewhere by the writer. Forbes and Richardson, however, say that it is in weedy branches of this stream. They also record it for the Kaskaskia system.
45. **Fundulus notatus** (Rafinesque), Top Minnow.
Common in those parts of large streams where the water is quiet and where there is much aquatic vegetation. Rarely found in small creeks.
46. **Labidesthes sicculus** (Cope), Brook Silversides.
Appears to be confined strictly to the Embarras River, for the writer has not found it elsewhere in the Charleston region. It is present in large numbers just below the dam and is scarce in other parts of the stream fished in the neighborhood of Charleston.
47. **Aphredoderus sayanus** (Gilliams), Pirate Perch.
A few taken from the Kaskaskia system. It undoubtedly occurs in the Embarras streams in small numbers for it has been taken in these in Douglas county by the writer.
48. **Pomoxis annularis** Rafinesque, White Crappie.
Frequently caught by hook in the Embarras River, and it is abundant in the Mattoon Reservoir, which belongs to the Little Wabash system. No records have been obtained for regions other than these.
49. **Pomoxis sparoides** Lacepede, Black Crappie.
Abundant in the Mattoon Reservoir. Not found elsewhere in Coles county by the writer.
50. **Ambloplytes rupestris** (Rafinesque) Rock Bass.
Locally common in the Embarras and larger tributaries. Prefers waters having large rocks. Forbes and Richardson have found it in the Kaskaskia River near Coles county.
51. **Chaenobryttus gulosus** (Cuvier and Valenciennes), Warmouth Bass.

Probably occurs in the Embarras River, judging from descriptions given by anglers. None found in the region by the writer. Forbes and Richardson record it for the Kaskaskia in Coles county.

52. **Lepomis cyanellus** Rafinesque, Blue-spotted Sunfish.
Abundant; the most widely distributed of any species of fish in the region. Found in all types of fish-bearing streams and in ponds, but it prefers deeper, quieter portions of small creeks.

53. **Lepomis megalotis,** (Rafinesque), Long-eared Sunfish.
Abundant in rivers and large creeks. Scarce in small creeks. The most common sunfish in our larger streams. It is an important species from the standpoint of local anglers.

54. **Lepomis humilis** (Girard), Orange-spotted Sunfish.
Common in Flat Branch, and some have been taken from the Kaskaskia River. No records for it in the Embarras system near Charleston, but it has been found in this system in Douglas county.

55. **Lepomis pallidus** (Mitchill), Blue-gill.
Only one taken by the writer in the region, and that was from Kickapoo Creek. Forbes and Richardson record it for the Kaskaskia near Coles county.

56. **Micropterus dolomieu** Lacepede, Small-mouthed Black Bass.
A few specimens have been taken by the writer in the Embarras River, Polecat Creek, and Kickapoo Creek during the present year, 1913. None have been found by him prior to this year, although it was recorded for the Charleston region by Forbes and Richardson.

57. **Micropterus salmoides** Lecepede, Large-mouthed Black-Bass.
Abundant in the Embarras River and in its tributaries not far from the main stream. It prefers the deeper water of these streams and is most frequently found about masses of submerged tree roots. None are present in my collections from the Kaskaskia system, although Forbes and Richardson record it from there.

58. **Stizostedion canadense griseum** (De Kay), Gray Pike.
Taken in the Kaskaskia system close to the west boundary of Coles county, according to Forbes and Richardson.

59. **Percina caprodes** (Rafinesque), Log-Perch.
Uncommon. A few have been taken from the Embarras River, from the Kaskaskia River and from Kickapoo Creek.

60. **Hadropterus phoxocephalus** (Nelson).

Uncommon. Taken from the Embarras and Kaskaskia Rivers but not from any of their tributaries.

61. **Hadropterus aspro** (Cope and Jordan), Black-sided Darter.
Common in the Embarras and in the Kaskaskia Rivers and in large creeks. Scarce in small creeks.

62. **Hadropterus sciurus** Swain.
Apparently very rare. Two were taken by the writer in the Embarras River.

63. **Diplesion blennoides** (Rafinesque), Green-sided Darter.
Abundant in certain parts of the Embarras River and its larger tributaries, where the water is shallow and swift and where thre are considerable algae (Cladophora.) None have been found in small creeks; and there are no records for the Kaskaskia system.

64. **Boleosoma nigrum** (Rafinesque), Johnny Darter.
Abundant; chiefly in rivers and large creeks.

65. **Boleosoma camurum** Forbes.
One taken in the Kaskaskia River by the writer. This is the only record for the region.

66. **Ammocrypta pellucida** (Baird), Sand Darter.
Found in considerable numbers in some parts of the Embarras River where the bottom is sandy. Not obtained from any other stream in the region.

67. **Etheostoma jessiae** (Jordan and Brayton).
Rare; one taken from the Embarras River and one from the Kaskaskia River in Coles county, by the writer.

68. **Etheostoma caeruleum** Storer, Rainbow Darter.
Abundant on stony shoals in the Embarras River and in its larger tributaries. Uncommon in small creeks. No records have been obtained for the Kaskaskia system. in the Charleston region.

69. **Etheostoma fiabellare** (Rafinesque), Fan-tail Darter.
Often taken in the Embarras and in its larger tributaries; not abundant anywhere. No records for the Kaskaskia system in the Charleston region.

70. **Boleichthys fusiformis** (Girard).
Only one taken in the region by the writer, and this was from the Embarras River. This is the only record obtained for the region.

Summary and Conclusions.

Records of seventy species of fish occuring in the vicinity of Charleston, Illinois, and within the boundaries of Coles county, have been obtained.

Besides these seventy species, there are, according to the distribution data given in Forbes and Richardson's work on the Fishes of Illinois, twenty-three species that possibly oc-

cur about Charleston, but no authentic instance of their being found in the region has come to the knowledge of the writer of this paper. These are given in the following hypothetical list

Lepisosteus platostomus Rafinesque, Short-nosed Gar.
Anguilla chrysypa Rafinesque, American Eel.
Hiodon alosoides (Rafinesque), Northern Mooneye.
Ictiobus cyprinella (Cuvier and Valienciennes), Redmouth Buffalo.
Ictiobus urus (Agassiz), Mongrel Buffalo.
Ictiobus bubalus (Rafinesque), Small-mouthed Buffalo.
Moxostoma anisurum (Rafinesque), White-nosed Sucker.
Phalcopharynx duquesnei (Le Sueur).
Notropis heterodon (Cope), Black-chinned Minnow.
Notropis gilberti Jordan and Meek.
Notropis jejunus (Forbes).
Ictalurus furcatus (Le Sueur), Blue Cat.
Ameiurus nebulosus (Le Sueur).
Noturus flavus Rafinesque, Stonecat.
Fundulus dispar (Agassiz).
Lepomis mineatus Jordan.
Eupomotis heros (Baird and Girard).
Stizostedion vitreum (Mitchill).
Hadropterus ouachitae (Jordan and Gilbert).
Cottogaster shumardii (Girard).
Crystallaria asperella (Jordan).
Etheostoma zonale (Cope), Banded Darter.
Etheostoma squamiceps Jordan.

There are thirty-eight of the seventy species recorded about Charleston that may be considered either common or abundant. A list of these is given in the table on pages 104-5.

One of the most interesting features concerning the distribution of fish in the streams about Charleston is the dissimilarity between the fish faunas of the Kaskaskia and the Embarras systems in the region. There are five species in the latter that are either absent or very scare in the former. These are the stone-roller, Storer's chub, brindled stonecat, green-sided darter, and the rainbow darter; and then there are six species, each forming quite a conspicuous part of the Kaskaskia fish fauna, which are absent of very scarce in the Embarras system about Charleston. These are: the spotted sucker, silvery minnow, river chub, tadpole cat, pirate perch and orange-spotted sunfish. These faunal differences are not remarkable when we consider that the two streams are in very different drainage basins, the Mississippi and the Wabash; but they signify a marked distinctness of the two systems geographically in the Charleston region.

Each of the species of fish most carefully studied favors certain types of streams and certain places in these streams. A study of the factors that determine these preferences is now being made, and the results of this work are intended for other publications. Some notes on these habitat preferences are given in this paper in the annotated list and in the table.

The Charleston region is well adapted for the study of the local distribution of stream fish, for there are many streams present, and these are of a number of different types. They are also located in country of two distinct kinds, prairie and wooded morainal, each of which is typical of that found in large portions of our state. The streams are also interesting because they are along the line, separating the Lower Illinois Glaciation from the Wisconsin Glaciation. These two regions are very distinct ichthyologically, as shown by the work of Forbes and Richardson. The Coles county fish fauna is most like that of the Wisconsin Glaciation.

THE DISAPPEARING BEAVER.

ELLIOT R. DOWNING.

In a bulletin of the State Biological Survey on the Mammals of Champaign County, the statement was made that in the early days the beaver was an inhabitnant of Illinois. Now, there probably are none of the animals left within the state. It has been my good fortune to follow it in its retreat to regions where it still is abundant. The book that is still the American classic on the beaver was written by Morgan, who made most of his observations upon the beaver in northern Michigan. I lived as a boy in the neighborhood of the streams where he saw these animals and have recently had the chance to watch them at work in this same region. My early interest was one of curiosity merely; my later purpose in studying the work of the animal, to see in how far the skill which he displays is a result of instinct and how far it is a matter of intelligence. No other animal leaves such extensive workings and hence the beaver is an exceedingly good subject for the study of animal behavior, since the record of his work is easily read and relatively permanent.

Permit me to give a brief resume of the life hibits of the animal as observed in northern Michigan. In the deeper streams where the banks are steep, the beaver does not build the dam, but excavates a burrow in the bank. There are many colonies of these bank beavers in the Upper Peninsula streams. Usually, however, especially on the smaller

streams, the beaver-dams are conspicuous objects. The dams are built of tag-alder principally, with poplar and birch. The tag-alder is an almost constant border tree along the streams. I have seldom seen any indication that its bark is used for food, but it is extensively cut to form the dams. These dams are usually rather loose structures, the chinks of which are filled in by floating debris that is entangled in the brush cut and piled by the beavers. Many of the dams have the appearance of being constructed by the accumulation of the stripped poles and logs that have floated down from the beaver pond and lodged in the pile of alder brush which initiates the dam. The dams usually bend down stream and will vary from a few yards in length to many hundred feet. The long dam in the accompanying map was 256 feet in length. Morgan records dams three times this length. The dam varies in height from a few inches to several feet. I recall one dam on the branch of the Huron River that was something over 300 feet long and some 12 feet high at its highest point. In the beaver pond the houses are built and near the house in the fall there is accumulated a pile of brush made up ordinarily of poplar branches,—that is the store of food for winter.

Beavers are vegetarians and feed on bark and tender twigs of the poplar, occasionally on birch and other trees, but the poplar is the staple article of food. Populus tremuloides and grandidentata are the common forms in northern Michigan. Succulent roots and tender shoots of many of the plants growing along and in the streams are also eaten during the spring and summer. In the fall, most activity is seen in the beaver colony, for then the dam and houses are repaired and the winter stores accumulated. The poplar trees are cut while the beaver sits upon its haunches, supported in part by the tail, and the stump is usually from 16 inches to 20 inches in height. Poplars from 4 inches to 6 inches in diameter seem to be the favorites, but much larger trees are cut down up to 18 inches. Larger cuttings are reported, but I have never observed them in the northern woods. The branches are trimmed off the trees, the trunks cut into convenient lengths, three feet to six feet long and the branches and logs are transported to the pond to be piled in the heap of winter food. Not infrequently one finds a stump showing one cutting running halfway through it, which had evidently been abandoned by a beaver, then a second beaver has finished cutting down the tree, but instead of completing the cut started by the first beaver, he made a new one three inches to four inches above the first partial cut. In several instances, trees had been cut off by the beavers, but instead of falling the butt of the tree had slip-

ped off of the stump and was held upright, its branches being entangled among neighboring branches. Near a rather flat topped hill some fifty feet above the level of Dead River near Marquette, Michigan, there was an old dam; from just above this dam, as also from Rainy Creek on the other side of the hill, canals had been cut across the rather level ground to the base of the hill in order that the poplars growing on the sides of the hills might readily be transferred to the streams. The canal running just above the dam to the mouth of the ravine was about 130 feet long. Down the steep hillsides were worn well used slides down which the beavers coasted their logs. Some poplar trees on the sides of the ravine had been cut and in falling had fallen across the ravine and lodged with the butt on one side and the top on the other. The beavers were evidently puzzled to meet this situation. The top had been gnawed as also the butt, irregularly, but a dozen such trees had been abandoned.

Apparently we have a mixture of keen intelligence and inexplicable stupidity from this same animal and I am not prepared as yet to state any definite conclusions regarding the degree of intelligence.

PRACTICAL CLOUD STUDIES.

M. L. FULLER.

Weather forecasting the world over is done principally by watching the shift and development of the high pressure areas and low pressure areas shown on the daily weather maps. These maps, as is well understood, are prepared from data furnished by simultaneous observations telegraphed at regular hours, usually twice each day, from all stations in the country; and a study of consecutive maps indicates the direction and the rate of movement of the Highs and Lows that appear thereon, and the principal features of weather and temperature that accompany them. In this way the probable weather for a given state or locality is estimated for one or two days in advance and the estimate is issued as the official forecast.

The work of forecasting is complicated by the great variation that occurs in both the direction and the rate of progress of the Highs and Lows and in the distribution of cloudiness and precipitation about the Lows. While the pressure areas in temperate latitudes almost invariably move eastward, their paths may be at almost any eastward angle and may change from one to another on short notice. And their speed may vary from almost nothing to a thousand

miles or more per day. Also, though the distribution of clouds and precipitation about a Low is occasionally symmetrical and uniform, it is nearly always irregular and uneven, and one scarcely sees two maps in ten years that are exactly alike. Especially in the summer half of the year is the arrangement of the clouds and rain of a Low usually very erratic. The showers are generally of relatively small extent, with much clear or partly cloudy sky between, and there is often little or nothing on the map to indicate even approximately what localities will receive rain and which ones will be missed.

Since the occurrence or non-occurrence of precipitaation is in many respects and for most people the most important of the weather elements for the larger part of the year, and since rain or snow is always associated with cloudiness, and since this precipitation is usually preceded by certain distinct types of clouds, and attended by other types, and followed by still others, it would seem that a study of the cloud forms and developments and movements ought to yield some assistance to one interested in foretelling the weather. This has resulted in the experience of the writer.

Rain is nearly always preceded several hours, or a day or more, by cirrus of cirro stratus clouds, though sometimes these are obscured by lower clouds and can only be seen through an occasional break in the lower layer. The appearance and movements of cirrus and cirro-stratus should be carefully noted, as these clouds do not always indicate rain. Among numerous types of cirrus indications are the following.

Cirrus spreading rather rapidly from west and thickening toward the horizon usually indicate that a storm is approaching or developing in the west. If the movement of the individual clouds is from the west the storm will probably advance over your locality arriving in about average time. But if under a similar arrangement and appearance of cirrus, the movement of the individual clouds is from S. W. or S .S. W., the approach and passing and departure of the storm will usually be slower, there is likelihood of more rainfall, and the clearing will be delayed longer, than with the first type of cirrus, even though the weather maps in both instances should be alike.

Cirrus or cirro-stratus moving rapidly from S. W. to N. E., or from W. S. W. to E. N.E., and covering or crossing the upper half of the southern sky, will be followed by rain or snow next day four times out of five. (There is one set of conditions under which this rule will not hold). If the movement of cirrus is from nearly due west and crosses only the

southern sky, the chance of rain at your locality is less, as the storm may pass to south of you.

Cirrus in the lower half of the northern sky, having the form that seems to spread outward from the northwest, but at the same time moving from due west, indicate rain to north and northeast of your locality within probably 12 hours. A similar appearance in the north with the cirrus covering the northwest sky and moving rapidly out from the northwest toward the zenith, indicates rain at your locality usually within 12 hours.

Scattered cirrus and cirro-stratus frequently mark or indicate the path to be followed by summer showers. Sometimes cirrus merged with alto-stratus do the same. Alto-cumulus and the higher type of strato cumulus often mark the path of showers to follow. That is, one may quite often know from these clouds that showers moving from the west will pass to north of his locality within 4 to 10 hours; or that they will first develop to the north or northwest and will later overspread his vicinity; or that they are likely to occur only to the southeast of him. Alto cumulus in early morning, moving from west or southwest over or near the zenith, and unaccompanied by approaching storm clouds, indicate thunder showers the following mid-afternoon or evening.

There is one combination and sequence of cirrus and alto-stratus in afternoon and early evening that indicates rain with thunder for the following morning or early forenoon nine times out of ten. This combination has been used successfully in evening to predict rain for the following morning when even the P. M. weather map of the day did not show any storm approaching or developing.

In a similar manner clouds often enable one to know whether an approaching shower is likely to be heavy or light; or when rain now in progress will cease; or whether at the end of one shower another is soon to follow; and numerous other features of interest or value.

The foregoing illustrates what may be done by cloud study. The rules given will apply in the northern half of Illinois and the most of Iowa, and in most of the surrounding states with probably slight modifications. For other sections of middle and eastern United States further changes would doubtless be required, but the same methods could be used to advantage.

To use these suggestions it is of course necessary to be acquainted with the standard classification of clouds. A considerable fund of personal observations and experience is also essential to familiarize one with the cloud types mentioned, as these can not always be accurately recognized from a mere verbal description.

The purpose of this paper is simply to suggest lines along which practical use may be made of cloud observations that any intelligent person with opportunity to view the sky may readily make for himself.

STRATIGRAPHY OF THE CHESTER GROUP IN SOUTHWESTERN ILLINOIS.

STUART WELLER*

Introduction.

The earlier work on the stratigraphy of the Chester group in southern Illinois was done by Swallow, (1) Hall, (2) Engelmann, (3) and Worthen. (4) No attempt will be made in this place to review in detail the work of these several observers. It is sufficient to state that after the publication of Worthen's reports of the Geological Survey of Illinois, a fairly well defined series of rock strata, at the summit of the so-called Sub-Carboniferous or Lower Carboniferous series, having their typical development in Randolph County, were commonly known as the Chester group. Hall had applied the name of Kaskaskia to the greater part of the same series and the names Kaskaskia and Chester were commonly considered as being synonymous. Rocks having similar lithologic characters and with the same fossils, were recognized in other states further south, notably in Kentucky and Alabama, and the same names, either Chester or Kaskaskia were applied to them. The total thickness of the rock strata to which these names were applied was 800 or more feet.

No serious attempt was made to subdivide this Chester group until the publication by Ulrich and Smith of a report on "The Lead, Zinc and Fluorspar Deposits of Western Kentucky" in 1905 (5). In this report Ulrich proposed to divide the entire group into three major formations, the Ste. Genevieve limestone below, the Cypress sandstone, second, and the Kaskaskia limestone above. The name Ste. Genevieve had been used by Shumard (6) for a limestone in Missouri, which comprised a part of the Ste. Genevieve of Ulrich. (6) The name Cypress had been proposed by Engelmann in the same sense as used by Ulrich, this sandstone being the basal member of the Chester group of Worthen. Kaskaskia was a revival of Hall's name which was originally applied to the beds lying above the Cypress sandstone of Engelmann. The

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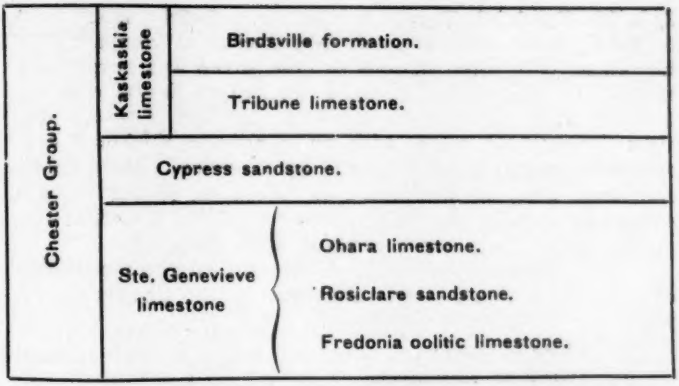

subordinate members of the Ste. Genevieve limestone, Fredonia, Rosiclare, and Ohara, were used for the first time by Ulrich in this report, as were also the names Tribune and Birdsville, the two formations in which the Kaskaskia limestone was divided.

The most notable innovation in Ulrich's classification, is the inclusion of the Ste. Genevieve limestone in the Chester group. Engelmann had recognized two Chester beds in Johnson and other southern counties in Illinois, which he believed to be sub-Cypress in position, and to these two supposed sub-Cypress beds Ulrich gave the names Rosiclare sandstone and Ohara limestone and included them in his larger Ste. Genevieve limestone. The distinguishing features of Ulrich's Ste. Genevieve is a lithologic succession, limestone below and above with an intermediate sandstone member, rather than any faunal character.

The detailed field work of the writer during several seasons, upon the Chester formations in the Waterloo, Renault, Baldwin and Chester quadrangles, comprising parts of Monroe and Randolph counties, has led to some important conclusions in the interpretation of this upper portion of the Mississippian section, which are not wholly in accord with the classification of Ulrich. The detailed observations by Worthen and other earlier geologists, were confined mainly to the sections in the Mississippi River bluffs and although the Chester rocks were recognized at many points in the interior, no serious attempt was ever made to establish exact correlations between them and the beds in the bluff sections. A careful study of the Chester beds which are widely exposed in the stream valleys back from the Mississippi River bluffs, has greatly magnified the importance of the lower members of the section. Worthen's lower limestone, bed No.

2, in his Randolph County section, immediately superjacent to the Cypress sandstone, was described as a "compact gray limestone, with intercalations of blue, green and purple clay shales," 150 feet thick. The more detailed studies have shown this bed to be a composite member, made up of several distinct formational units, with an aggregate thickness considerably greater than estimated by Worthen. The Cypress sandstone also, as interpreted by Worthen, proves to be a composite member the higher beds comprising a distinct formation which rests unconformably upon the lower.

These detailed studies have necessitated the recognition of a series of nine distinct formations in the Chester group, which are designated as follows:

9. Clore formation.
8. Palestine formation.
7. Menard formation.
6. Okaw formation.
5. Ruma formation.
4. Paint Creek formation.
3. Yankeetown formation.
2. Renault formation.
1. Brewerville sandstone.

Each of these formations possesses distinct lithologic and faunal characters by which it may be easily recognized, and all of them may be readily traced and mapped throughout the region studied. Ulrich's division of the supra-Cypress portion of the Chester into the Tribune and Birdsville formations has not been carried out in detail by him in the Randolph and Monroe county area, but he has stated (7) that he considers the summit of the limestone ledge quarried in the Southern Illinois Penitentiary near Chester, to be the dividing line between the Tribune and Birdsville. Under this interpretation the Tribune of Ulrich would include the Okaw, the Ruma, the Paint Creek, the Yankeetown and part of the Renault formations, leaving the Menard, the Palestine and the Clore as the equivalent of the Birdsville. Furthermore, all the formations from the summit of the Okaw downward to some point within the Renault, have been differentiated from Worthen's 150 foot limestone member immediately superjacent to the basal sandstone or Cypress member in his Randolph county section. It will be understood from this statement, therefore, that the most important results of these recent studies have been in magnifying the importance of the lower portion of the Chester group, these members of the group having their more typical development, not in the Mississippi River bluffs, but in the region between the Mississippi and the Okaw or Kaskaskia valleys.

The general characters of each of the formational units designated above will be outlined here.

1. Brewerville Sandstone.

General characters. In its original application by Engelmann, the name Cypress was used to designate a series of "quartzose sandstones with some shaly portions, about 150 feet thick," which have a prominent development on Cypress creek in Johnson county. The same formation was recognized by Worthen in the Mississippi river bluffs below Prairie du Rocher, although he never used the name Cypress, referring to it always as "the lower sandstone of the Chester group." The thickness of the formation, as recognized by Worthen, was "from 50 to 100 feet or more." Excellent exposures of the formation in the Randolph-Monroe County area, are to be seen in the Mississippi river bluffs immediately above Modoc, and in the ravines between Modoc and Prairie du Rocher, also in the valleys of the north and south forks of Horse Creek and their tributaries west of Red Bud, in the valley of Rock House Creek southeast of Waterloo, and in the valleys of Prairie du Long Creek and its tributaries east and northeast of Waterloo.

It was apparently the purpose of Englemann, and also of Worthen, to include in the Cypress formation all the essentially arenaceous beds in the basal portion of the Chester group, and Ulrich's interpretation also conforms with that of these earlier writers, although he states that "in the most complete development of the formation it is divisible into three members or beds." (5) The upper member is said to include thin-bedded and slightly argillaceous strata, the lower member being apparently always massive. The middle bed of Ulrich, "a highly fossiliferous, cherty, blue, fine-grained limestone, rarely more than four or five feet thick," is said to lie 60 feet to 80 feet beneath the top of the formation.

The field studies of the writer have shown that these lower arenaceous strata of the Chester group are divisible into two distinct formations, separated by an unconformity and overlap. For the lower of these formations, which includes the more massive basal member of the Cypress as that term was used by Engelmann and by Ulrich, the name Brewerville is proposed.

The formation is a very massive, fine or medium grained sandstone in thick beds, often more or less conspicuously cross-bedded. Its color on freshly broken surfaces is a soft brown tint, which in some localities becomes nearly white. Not infrequently it is mottled with small, darker brown specks. On long exposed, weathered surfaces, the color in

most localities is a darker brown than that of freshly broken surfaces. Wherever the streams have eroded their channels in this massive sandstone formation, picturesque gorges have been formed with nearly vertical walls. The maximum thickness of the formation probably does not exceed 70 or 80 feet, and practically the entire maximum thickness is exposed in the Mississippi river bluffs, two miles above Modoc, and in the bluffs of Rock House Creek, three and one-half miles southeast of Waterloo. To the eastward, north of Prairie du Rocher, the formation thins out entirely, the superjacent Renault formation resting, by overlap, directly upon the St. Louis limestone.

Sub-Brewerville unconformity. Throughout the Randolph-Monroe county area, the Brewerville rests unconformably upon the underlying formations. The subjacent limestone floor in most of the area is the St. Louis limestone, but in the Mississippi River bluffs below Prairie du Rocher, and in some of the ravines southeast of the same town, a remnant of the Ste. Genevieve limestone is still present. The demonstration of the unconformity, however, is not alone dependent upon the absence of the Ste. Genevieve in part of the area. At the close of the erosion period during which the Ste. Genevieve limestone was wholly removed over a large area, the resultant surface was uneven, although with no abrupt relief features. Where the actual contact of the Brewerville upon the underlying strata can be seen, as in the bluffs between Prairie du Rocher and Modoc, the difference in elevation of the contact, as well as the different strata at the summit of the subjacent formation, are clearly discernable. A difference in elevation of the contact line, of at least 100 feet in a distance of one mile or less, is observable west of Red Bud. Furthermore, at many localities on the north fork of Horse Creek and its tributaries, and in Rock House Creek, the basal bed of the Cypress is a conspicuous layer of breccia, one foot or more in thickness, made up of angular masses of the very characteristic chert from the upper St. Louis limestone beds, these masses ranging in size from a fraction of an inch to a foot or more in the their maximum dimension.

2. Renault Formation.

General characters. The Renault formation consists of an exceedingly complex series of strata whose lithologic characters change rapidly both in horizontal extent and vertically. The formation includes sandstones, arenaceous shales, variegated green, blue and purple shales, calcareous shales, thin platy layers of limestone in some of the calcareous shales, dense arenaceous limestones, nearly pure crystalline limestones, oolitic limestones, and in the northern part of

the Waterloo quadrangle, limestone conglomerate. The formation undoubtedly includes some portion of the "lower sandstone of the Chester group," of Worthen, and it is believed that Ulrich's middle and upper divisions of the Cypress in Kentucky should be referred to the Renault. The thicker bedded sandstone and the arenaceous limestone strata of the formation are conspicuously cross-bedded in almost every locality where they are exposed. In general the sandstones are thin-bedded with shaly partings, passing imperceptably into arenaceous shales. In many localities thin flaggy beds of sandstone are pierced by closely crowded, vertical burrows a quarter of an inch or less in diameter which in a weathered condition, occur as more or less complete perforations of the beds. Some of the heavier sandstone layers closely simulate the massive Brewerville. Such beds usually occur, when present, in the higher portion of the formation and rarely or never attain a thickness of over 10 to 20 feet. They may be distinguished from the Brewerville, not only by their less thickness, but also by the presence of the underlying shales, often variegated, sometimes by underlying limestone strata, and they usually contain some more or less fragmentary fossils.

The Renault formation is typically developed in the eastern portion of Renault township in Monroe county, where excellent exposures may be seen in the valleys of the two forks of Horse Creek and their tributaries. Good exposures may also be seen in the stream valleys northeast, east and southeast of Waterloo. Towards the western border the formation is composed almost entirely of arenaceous strata. Eastwardly the thickness gradually increases until it attains its maximum of from 80 to 100 feet; the calcareous strata also become more conspicuous towards the east, where important crystalline limestone beds are developed. The variegated shales have a conspicuous development in the basal part of the formation in the region northeast of Waterloo, where an important bed of these sediments, 25 feet or more in thickness, is frequently exposed in the valleys of Prairie du Long Creek and its tributaries. Similar, but less extensive beds of the same general character, occur elsewhere in the formation, and they may be expected almost anywhere within the area of outcrop.

The Renault overlap. In its geographic distribution the Renault formation is much more widespread than the subjacent Brewerville, since through much of its area it overlaps the Brewerville along its western border, and rests directly upon the St. Louis or Ste. Genevieve limestone, the actual amount of overlap observed in the Renault quadrangle being at least two miles. The unconformable relations of the

Renault with these limestones, when they are the immediately subjacent rocks, is very clear, and in one point in Hickman Creek, about two miles west of Millstadt, in the northern part of the Waterloo quadrangle, an important bed of limestone conglomerate is present in the base of the formation. At this locality the conglomerate rests directly upon the Ste. Genevieve limestone, and the rounded pebbles in the conglomerate are mostly from the immediate underlying Ste. Genevieve beds. The unconformity of the Renault upon the Brewerville is not so obvious, but it seems to be clearly established. The arenaceous character of the higher formation, especially towards its western border, sometimes makes it difficult to determine exactly the line of contact between the two formations. In several localities, however, where the Renault is represented by calcareous beds and the Cypress is possessed of its typical, massive, unmistakable characters, there are notable discrepences in the elevation of the contact between the two formations within rather short distances, which would indicate an erosion interval preceeding the deposition of the younger formation. Furthermore, in a tributary of Hickman Creek, two and one-half miles northeast of Millstadt, the Renault rests upon the Brewerville with a limestone conglomerate in the base of the formation.

3. Yankeetown Formation.

General characters. The Yankeetown formation, although a thin stratum which probably never exceeds and rarely attains 20 feet in thickness, is one of the most persistent members in the Chester group of the Randolph-Monroe county area. In all its outcrops where it has been exposed to long weathering, the formation is almost completely siliceous, the color usually being light buff or nearly white. Where it has not been subjected to such long weathering, or where it has been encountered in digging wells, it is commonly, in part at least, composed of highly siliceous limestones; some of the beds are slightly sandy, and locally the formation is partly quartzitic; where this quartzitic facies is best developed, on Hickman Creek in the northern portion of the Waterlo quadrangle, the color is distinctly red or rose. The bedding of the formation is commonly very irregular and contorted.

In its geographic distribution the Yankeetown extends from the extreme northern portion of the Waterloo quadrangle to the Mississippi river bluffs, about two miles below Modoc, near the southeastern corner of the Renault quadrangle, where it passes beneath the younger formations. The bed is so resistant that in many localities it is well exposed in stream beds where other members of the Chester are en-

tirely covered, and in regions where the drift mantle is not excessively thick the position of the formation can be detected in the public highways, and frequently in the fields, by the presence of the characteristic chert-like fragments in the soil. In the valleys and the ravines the Yankeetown outcrop is reduced to a mere line on the map, but upon some of the divides it is the underlying rock over considerable areas because of its resistant character, such being the case southeast of New Design and east of Renault. Some excellent and typical exposures of the formation may be seen in the region about Yankeetown school, from which exposures, the name of the formation has been derived. Northwest and southwest of Millstadt, in the northern portion of the Waterloo quadrangle, the Yankeetown constitutes the floor upon which the Pennsylvanian beds have been laid down and it is exposed in some of the stream beds which have been cut through the Pennsylvanian.

In its stratigraphic relations with the subjacent Renault formation, the Yankeetown is believed to be unconformable, although the unconformity can possibly not be established with entire satisfaction. At different localities the higher formation rests directly upon the very different beds of the Renault, sometimes upon sandstone, sometimes upon limestone and sometimes upon shale. Furthermore, the underlying Renault varies in thickness beneath the Yankeetown from 40 feet or less to more than twice that thickness. If the Yankeetown was not deposited unconformably upon the Renault, there must have been an abrupt transition from the remarkably heterogeneous conditions, as evidenced by the variable sediments of the Renault, to the wonderfully uniform sedimentation of the Yankeetown.

4. Paint Creek Formation.

General characters. The Paint Creek formation succeeds the Yankeetown with apparent conformity, and is very uniform in its characteristics throughout the entire Randolph-Monroe county area. Its thickness is from 60 to 80 feet, the average thickness probably not much exceeding 60 feet. The lower half of the formation, or perhaps somewhat more than half, is almost entirely shale, while the higher portion is largely limestone with shale partings.

In the lower portion of the formation occurs one of the most peculiar and most persistent beds in the whole Chester group. It is a deep red, compact clay, without lamination or bedding planes, commonly without inclusions of any sort, but in at least one locality a number of irregularly rounded pebbles of Chester limestone, from one or two to several inches in diameter have been observed. The summit of this

bed is uniformly, in all localities where measurements have been possible, from 20 to 25 feet above the Yankeetown chert. The exact thickness of the red bed itself, however, cannot often be observed because of the weathering and slumping of the material over the underlying strata, but where the interval immediately above the Yankeetown has best been seen, a series of bluish calcareous shales with plates of limestone extends for several feet above the chert. The actual thickness of the red bed is probably about 12 or 15 feet in the natural outcrops which have been observed, and this thickness is confirmed by the records of several dug wells which have penetrated the stratum. When encountered in well digging the bed is very hard and tough and can be excavated only by the aid of blasting, but when exposed to the weather it rapidly breaks down into a fine red mud. On freshly exposed surfaces in creek banks this red clay first clumbles into angular fragments, usually a fraction of an inch in maximum dimension, and finally breaks down into a fine red mud. The origin of such a bed as has been described, persistent as it is through a distance of at least 30 miles in the Waterloo and Renault quadrangles, is not clear. In its physical characters it closely simulates certain beds of red residual clays, but such an origin for this stratum, occurring as it does conformably in the midst of typical marine sediments, seems to be out of the question. One of the best points to observe this member of the Paint Creek formation, as well as the higher members of the same formation, is the valley of the tributary of Paint Creek, entering from the south, situated about one and one-fourth miles southwest of the village of Ames.

The higher, more calcareous members of the Paint Creek formation, shaly below and passing into firmer limestone beds above, are well exposed in many localities in the Waterloo and Renault quadrangles. In some localities underlain by the limestones of the formation, numerous sink holes are developed in the topography, such a condition being present on the divide immediately west of Ames.

5. Ruma Formation.

General characters. Succeeding the upper limestone member of the Paint Creek formation, is a series of shales the sandstones, rarely if ever more than 40 or 50 feet in thickness. The shales usually predominate, but in all localities where the formation is well exposed, there are important, thin-bedded sandstone layers and some arenaceous shales near the middle of the formation. The more shaly beds are in almost all localities conspicuously variegated, being blue, reddish and purple in color, not unlike some of the shale

beds of the Renault formation. The Ruma formation is the highest formation in the Chester group in Randolph and Monroe counties in which conspicuous variegated shale beds have been observed. In at least one locality a thin limestone ledge, one or two feet in thickness, has been observed in the midst of the Ruma, but the occurrence of limestone in the formation is rare. Excellent and typical exposures of the Ruma formation may be seen in the stream valleys tributary to Horse Creek, west and northwest of the village of Ruma.

6. Okaw Formation.

General characters. The Okaw formation comprises a series of alternating limestones and shales which have an aggregate thickness of from 150 to 200 feet. The valley of the Kaskaskia or Okaw River is excavated through these beds at its junction with the valley of the Mississippi, and excellent exposures of the various members of the formation are present both above and below this point in the Mississippi River bluffs.

At least four, and perhaps five important limestone members are present in the formation, the uppermost of which is the quarry ledge at the Penitentiary. These limestones vary greatly in color from dark blue to gray and nearly white, the weathered surfaces of some strata being buff or brownish. The texture also varies from a very compact limestone to more or less coarsely crystalline beds, with some distinctly oolitic zones. One very persistent oolitic bed nearly white in color, occurs about 50 or 60 feet from the base of the formation. Most of the limestone beds are free from chert, although some cherty horizons are present in the formation. These calcareous members of the formation sometimes consist of rather massive beds of limestone, but more frequently the individual beds are a foot or less in thickness, separated by thin shaly partings.

The shale members of the Okaw formation, occupying the intervals between the limestones, are soft and easily acted upon by the weather, and consequently are rarely well exposed. Where they have come under observation in certain ravines, these shales are commonly blue or gray in color, rarely with a slight admixture of red or purple, which is such a conspicuous feature of some of the lower shale horizons.

The highest member of the Okaw, immediately above the quarry ledge at the Penitentiary, consists of calcareous shales with interbedded thin limestones, and locally a sandstone ledge 10 to 12 feet in thickness is present.

7. Menard Formation.

General characters. The Menard limestone is a conspicuous formation, well exposed in the middle portion of the bluffs at Chester. One of the best exhibitions of the formation is to be seen immediately southeast of the hospital for criminal insane at Menard. In its typical expression this limestone is thin and moderately thick bedded, the bedding planes being undulating and hummocky in character, with thin shaly partings. In places these shaly partings become thicker and shale beds of as much as five feet or more in thickness are present. The basal portion of the formation, where it is exposed, is seen to be shale, as much as 35 feet of fine, blue clay shale being present in some localities between the top of the Okaw and the typical limestone beds of the formation. The lithologic character of the limestone of the formation differentiates the Menard rather sharply from most of the limestone strata of the Okaw. The limestones of the lower formation are commonly more or less crystalline or granular, often crinoidal, sometimes oolitic and usually free from chert. In the Menard the limestones are nearly always close textured, fine grained rocks, and not infrequently carry a small amount of chert; they are brittle and often exhibit a conchoidal fracture. Because of the difference in texture the weathered surfaces of the Menard are commonly smooth, those of the Okaw usually being more uneven. The color of freshly broken surfaces of the Menard is usually a bluish gray while that of the Okaw limestone is commonly lighter, some beds being nearly white. Locally there are more crystaline strata in the Menard which closely resemble certain of the Okaw beds, but such strata are always of limited thickness and usually occur in the higher portion of the formation. The thickness of the formation is about 80 feet. It is well exposed in the Mississippi River bluffs from Chester to Rockwood, and the valley of Mary's River, at its mouth, is excavated entirely through this formation into the higher beds of the Okaw.

8. Palestine Formation.

General characters. The formation succeding the Menard is arenaceous throughout in most sections, consisting in part of heavy beds of sandstone suitable for building purposes, and in part of thinly bedded, ripple marked sandstones or arenaceous shales. Locally, however, more argillaceous shales are well developed in the formation. The formation is present in the higher portion of the bluffs at Chester, and has been quarried at several points for building stone. The buildings of the penitentiary at Menard are constructed of

this rock. The thickness of the formation is about 75 feet, and it seems to lie with some degree of unconformity upon the subjacent Menard limestone. The name of the formation is derived from Palestine township, in Randolph County, where excellent exposures may be seen.

9. Clore Formation.

General characters. The highest formation in the Chester group in Randolph County, is a limestone immediately overlying the Palestine sandstone. The greatest thickness actually measured in Randolph County is 30 feet, but it cercertainly exceeds this thickness in many localities. The passage beds from the underlying sandstone to the Clore limestone, consist of arenaceous and calcareous shales, with some beds of limestone, occupying, in places, an interval of as much as 25 feet below the more continuous limestone strata. The lithologic characters of the limestone beds are variable, some being thin bedded and almost shaly, others being similar to the Menard in texture and hardness, but usually darker in color, while others are more granular or crystalline. Some shale beds are included in the formation.

The Clore limestone caps the summits of the hills upon which the city of Chester is built, and it outcrops in the heads of several of the ravines adjacent to the town. The formation also caps other of the higher hills east and northeast of Chester exposures being present in the heads of the ravines on the southwest side of the high ridge extending from Clore school to the Randolph County Farm. The most extensive exposures which have come under observation are in Bremen township of Randolph County, about two miles northeast of the village of Bremen, where a small anticlinal flexure brings this limestone to a lower elevation and its surface outcrops spread out on either side of Little Mary's River.

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(1) Proc. Amer. Ass. Adv. Sci., vol. 11, pt. 2, p. 5. (1858).

(2) Trans. Albany Inst., vol. 4, p. 2 (1858); Geol. Surv. Iowa, vol. 1, pt. 1, p. 107 (1858).

(3) Trans. St. Louis Acad. Sci., vol. 2, pt. 1, p. 189 (1863); Geol. Surv. Ill., vol. 1, pp. 350-455 (1866).

(4) Geol. Surv. Ill., vol. 1, pp. 77-83, 284-292, 305-308 (1866).

(5) U. S. G. S., Prof. Paper, No. 36, pp. 24, 36-66. (1905).

(6) Trans. St. Louis. Acad. Sci., vol. 1, p. 406 (1859).

(7) This is not a published statement, but a verbal statement made in the course of a discussion of the problem with the writer.

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